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ABSTRACT

The main purpose of this report is to help improve the management, development, and implementation of one of the major innovations in the field of education in the last few decades, namely the use of computer facilities in education. Based on an investigation of relevant literature and upon the answers to an international questionnaire, it has grown into a guide for decision makers and researchers. Countries surveyed include the U.K., the U.S.A., the Netherlands, and Canada. It deals with such topics as educational technology and "classical" computer-based instruction; artificial intelligence; adjunct use of the computer in computer-linked subjects; knowledge-based systems in the "soft" sciences; influences from military, vocational, and industrial training; testing, and computer-managed instruction. Conclusions are summarized under six headings: general development and scale of work, the purpose of CAI projects, rated importance of suggested reasons for developing computer based learning, training of non-specialists and consultancy services, courseware development, and expectations of computer based learning. One general recommendation emerges: a rethinking of the organization, the financing, and goal-setting of development projects in this field. (VT)

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ONDERZOEK EN ONTWIKKELING VAN ONDERWIJS

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computer based learning 1

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FOREWORD

It is a policy of this Department for Research and Development of Higher Education to make it possible for a wide circle of interested persons to benefit from the material developed in connection with its research and educational activities.

The basic purpose of this report is to help improve the management, development and implementation of one of the major innovations in the field of education of the last decades, namely the use of computer facilities in the educational process.

With most technological innovations, it usually takes many years from the time an innovation is introduced for it to be adopted by the majority of whose who would benefit from it.
In this case, however, it is not so easy to understand why. In a system growing and changing as rapidly as the educational one there is a basic need for improvement, for more effectiveness, for the predictable outcome of the processes, and the like. Perhaps we can find the answer by asking whether our educational system fulfils the basic conditions for the succesful diffusion of innovations, such as less rigid structures, decentralized decision centres, temporary structures for change, personal mobility, multidisciplinary work, and adequate means of financing. If not, then perhaps we need a more radical innovation first: the creation of a completely new educational system.

This report is based on an investigation of relevant literature and upon the answers to an international questionnaire. Initially intended as a report on the "state of the art" it has grown, thanks to Anne Hawkins' thorough and careful work, into a guide for decisionmakers and researchers in the field of computer-based education.
We believe that the conclusion and recommendations in this report lead to one general recommendation: a rethinking of the organisation, the financing and goal-setting of development-projects in this field.

Drs. Gerard W. Ackers, director
Utrecht, June 1977

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Ours is a democratic department. I wish to express my sincere thanks and appreciation to all my colleagues who agreed that I should undertake this survey, and supported me throughout. Of my colleagues, my particular thanks go to Gerard Ackers and Wil Rigter for their help and advice over the form and clarity of the final version.

In the Netherlands, but outside this department, my thanks go to Bert Camstra and Mark Leiblum, who read the proofscript and made many helpful suggestions.

From the States, Karen Duncan was most generous in her help in contacting computer-based learning centres throughout ADCIS. At an earlier stage, drs. Bitzer, Bork, Bunderson, Deiss, Merril, Schuyler and Zinn completed the first group of questionnaires, and their reactions gave direction to the later work.

Prof. Ayscough of U.K. and dr. David Mitchell of Canada were also most helpful in providing important background information and guidance in the literature.

My warmest thanks must go to the sixty or more respondents who completed and returned their questionnaires. I hope they can all find reported here the points that they wanted to make.

Finally, for all that has been contributed by others, I must accept reponsibility for the treatment of the material and the conclusions that have been drawn from it.

C. Anne Hawkins
Utrecht, June 1977

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INTRODUCTION

This report ends with a summary and recommendations containing eight points directed to a better understanding of the factors facilitating the development of computer-based learning. It is preceded by the conclusions of the inquiry on which they are based. These conclusions are summarised in about 30 points, categorised under six headings, that are related to the headings and subsidiary items of a questionnaire.
The questionnaire was sent to centres of computer-based learning in tertiary education in a number of countries. Responses were received from almost every centre in the Netherlands and the United Kingdom. American centres were reached through the cooperation of ADCIS, and of the ninety American centres contacted, replies were obtained from thirty six.
The proportion from Canada was lower, because there was a postal strike at the time. Although so few in number, the Canadian responses form an important contribution, and have been included in the analysis of the questionnaires. A number of further responses was received which were of interest, but they were too isolated to permit useful comparisons or generalizations, and so have regretfully been omitted from the analysis.
Each project, however small or large, was asked to complete just one questionnaire. It would not have been feasible to expect everyone concerned with computer-based learning to respond on an individual basis. The results are reported per project representative. No attempt has been made to weight the responses by the size of the related projects. To do so would in any case have been misleading, since opinions differ within a group, and respondents were not asked to speak for their colleagues. Thus the replies should be considered to represent how sixty one people each working in a different centre at university level, perceive computer-based learning in general and their own situation in particular.
It may be argued that this distorts the representation of the present situation so obtained. The position is nevertheless defended on the grounds that at present the large projects dominate the literature, and the facts and opinions to be encountered in newer, smaller projects, are in danger of being ignored. This survey is concerned with the successful initiation and development of projects rather than an undirected survey of the present state of the art for its own sake. Further, there has been no attempt to go beyond providing a factual overview, and there is no statistical analysis of the data.
The questions directed to the respondent of each centre, the analysis of their replies and the conclusions drawn from them have been grouped under the following five headings:

1. The general development and scale of work of the centre
2. The purposes of the centre and of computer-based learning
3. The training of non-specialists and consultancy services that centres provide
4. How courseware is developed
5. How the future is envisaged

The report has been published in two parts. The first part provides an overview of the origins and contributory sources of computer-based instructional systems and the present situation in the United Kingdom, USA, The Netherlands and Canada.
The reasons why this survey was undertaken, the issues investigated, and the conclusions and recommendations drawn from them are also included in Part 1.

It is an important feature of this survey that development and opinions are considered too diverse at the present stage to permit a consensus view. Efforts have been made rather to do justice to that diversity, although groupings of development and opinion have also been put together. The distribution of development and opinion can only be truly ascertained through the detailed analyses. These have been given in full detail in Part 2. of the Report. It has been considered that these details will probably only be of interest to those whose primary interest is in computer-based learning. Those who are less directly concerned but who nevertheless wish to obtain Part 2. of the report can do so through this department.

Chapter 1

WHY THIS SURVEY WAS UNDERTAKEN

The University of Utrecht's project in computer based education (Project Computer Ondersteund Onderwijs) was established in 1975, with the following list of objectives:

1. to assess the present 'state of the art' of the use of CAI in higher education;
2. to assess trends of development;
3. to compare the costs and effectiveness of CAI with traditional education;
4. to advise on the implementation of CAI on a large scale within the university;
5. to develop and test CAI packages in at least three university departments;
6. to advise on an appreciation, innovation and implementation program;
7. to advise on the coordination of CAI activities.

This report is concerned exclusively with objectives 1, 2, 4, 6 and 7. At the commencement of the project, it was soon clear that these objectives could not be attained merely through a literature search, and that this survey would be required. Interest expressed in the survey was such that the presentation of this analysis of it now goes beyond the parochial requirements that first stimulated it.

Previous surveys

Two surveys and a general review which predate the present one have been considered. In the first of these, Anastasio and Morgan (1972) utilised the cumulative Delphi process in questionnaires followed by a conference of the respondents as the basis for their 'factors inhibiting the use of computers in instruction'.

The factors they identified clustered around the economic, educational and technical dimensions. Anastasio and Morgan rationalised the author-lag in materials development in the following "Catch 22" style quotation:

"In approaching the overall problem of CAI acceptance and use, it is helpful to recognize the existing circularity of the analyses. For example, the major educational question "How can evidence of effectiveness be provided?" evokes the following sequence of answers: To provide evidence of effectiveness, one must (a) conduct a convincing

high-quality demonstration. But (b) to conduct a proper demonstration, one needs good computer-based materials. But (c) to develop good materials, one needs good people, one needs professional recognition and economic incentives.
But (e) to get professional recognition, one needs evidence of the value of the pursuit (see point a) and to get proper economic incentives one needs a formal production-distribution system and market. But (f) to establish a production-distribution system and market, one needs a demonstration of effectiveness to convince potential investors and buyers of CAI's value - and we are back at the beginning".

In short, investment from commerce and support from the educational establishment awaits the production of prototype quality materials, which the potential authors fail to produce, since they are awaiting recognition for their work and financial incentives.

It would be less than just to dismiss their very thorough report with a couple of sentences, and more will be said of Anastasio's and Morgan's results when the present issues are charted.
At this stage it suffices to say that it is evident that factors of an organizational nature were largely ignored, and they need to be thoroughly investigated. It is of interest to note that organizational problems within their own CAI project were recognized and reported, and some generalizations over the inevitability of organizational problems within CAI were also made.

To comment further on the conclusions of Anastasio and Morgan, it must be said that CAI is no different from other educational innovations. Had these always had to await establishment support and financial reward, the rate of development of education over the centuries would have been too slow to perceive. The following quotation from Peter Smith's account of early work at Queen Mary College London's nuclear engineering department shows what the competent enthusiast can achieve (Smith 1975).

"The marginal costs of (our) first package were so small as to be negligible; no additional staff costs, no additional equipment costs, minimal costs of computing time and a small marginal cost associated with laboratory supervision. Given an available mini-computer and an interested member of staff willing to devote some of his time to this work, this was well within the resource capacity of any engineering department".

A comment from a man who is no doubt exceptional, but surely not unique and thus realistic in his exhortations and encouragement to others to make a start.

But most important of all, the appropriateness of the Delphi technique in this instance must be called in question. The origins of CAI are diverse, and the interests, backgrounds and locations of those working in the various aspects of it are equally scattered. The Delphi technique implies the possibility of a consensus, which, in the case of CAI , may not yet be considered capable of being established. With

most entertaining frankness, Anastasio and Morgan describe their procedures and, in the last paragraph of the quotation below, the confrontation that ensued when their seeking of a consensus met resistance.

"The sequence was to be as follows:

First Session: The group rates 83 statements on a 0-3 scale.

Second Session: The bottom two-thirds of the ranked list are considered; items not voted in are dropped; new suggestions voted in are added.

Third Session: Workshop A - rates items on general feasibility; discusses future technological developments and breakthroughs that might affect cost and prepares statements of these.
Workshop B - rates items on cost effectiveness and discusses those where there are divergent ratings; splits into sub-groups which define cost parameters of each item.

Fourth Session: Workshop A - discusses, rates, and prepares statements on any especially negative features of items in relation to special-purpose or "stakeholder" groups in education (e.g. handicapped students, teachers, vocational trainees).
Workshop B - estimates cost of items using the prepared cost parameters as guidelines; discusses and rates any especially positive values of items in relation to educational "stakeholder" groups.

Fifth Session: The material summarized from the workshops is distributed and discussed; the conferees individually allocate a limited budget among the items, in separate "Research and Development" and "Action and Implementation" programs.

This series of exercises, however, did not work out as planned. In fact, the course of the meetings bore little resemblance to the intended progression of inputs and evaluations. From the very beginning of the conference, the structure was questioned and even adamantly opposed by some of the conferees. This was due in part to misunderstanding, in part to the rigidity of the planned procedure, and in part to a fundamental problem which was symptomatic of organizational difficulties encountered throughout the study.

The misunderstanding ensued from a feeling that the planners had made some arbitrary assumptions and that the organization was not appropriate. Rather than serving as a minimally constraining framework for the conferees to interact within, as was intended, the format appeared to a number of conferees to be an interpretation with which they had to agree or disagree at the outset. Some participants felt their viewpoints could not emerge in such a framework, or be given enough weight. This was true in the sense that the planning of the conference was oriented much more toward gaining a consensus than toward exploring areas of divergence."

The second survey by Weathers and Williams (1976) was designed to determine the present (as of 1974) status of computer-based instruction and to evaluate the use of computer-based instruction in the training programs for astronauts and flight control personnel at the Johnson Space Centre, Houston, Texas. In their report the replies of 33 correspondents to 37 questions have been charted so that the individual, checked replies can be seen. A general flavour of the accompanying spontaneous response to each question is obtained from a selection of quotations from respondents under each one.
This concise, but useful, overview is presented by Weathers and Williams without the benefit of their conclusions, or the consequences for the NASA training program. The inappropriateness of seeking an overall consensus at this time is confirmed by their implication that not even isolated issues under particular questions are capable of summary and generalization. The number of respondents was probably too small to permit the identification of groupings within it.

One other study will be mentioned here. A comprehensive study of the problems of implementing computer-based instruction has recently been published by Seidel and his colleagues of HumRRO (the Human Resources Research Organisation) (Hunter et al, 1975). They have drawn their findings from a wide study of educational technology literature, and have presented a number of interesting and useful case studies, albeit entirely related to the American scene. (Not one non-American reference was to be found).
They acknowledge the cooperation of some forty specialists. Other than the implicit assumption that their book is for American consumption, their summary of findings, conclusions and recommendations is addressed to an undefined audience. While it may include food for thought for all, it would be difficult for those seeking specific advice in setting up a computer-based learning system, with all that that entails, to find it here. They group their conclusions concerning the necessity of computer-based instruction under four headings, which are as follows:

1. Computer Literacy
2. Educational Reform
3. Educational Efficiency
4. Curriculum Enhancement

The fourth, typical also of the other three, is quoted below to show the assumptions that still so often take the place of hard evidence and coherent argument in this field.

"4. Curriculum Enhancement. If one assumes the continuation of the information explosion and the pressures on individuals to acquire more and more knowledge in shorter and shorter time, it seems apparent that computer-based methods of learning would be among several innovations much in demand. If students are to acquire two or four times the knowledge in the same amount of time, it seems obvious that they must be armed with more efficient methods of learning than presently seen in traditional curricula. Computers will be used as an everyday tool by the student, not just to perform time-consuming computations and information retrieval, but also to help him focus on major concepts, complex problems, and powerful methods of studying complex phenomena."

Recommendations to professional societies and curriculum groups, to commercial publishing firms, to state departments of elementary and secondary schools, to the National Institute of Education, the U.S. Dept. of Labour and the National Science Foundation then follow. The recommendation to commercial publishing firms is given as an example.

"Recommendations:
2. Commercial publishing firms should reevaluate publishing plans and policies in light of a careful review of the above assumptions to determine whether there are areas of potential commercial development."

As vague as they are far reaching, such recommendations are doubly guaranteed to result in inactivity. Yet there is much in the body of the book that is of value to the converted (or at least sympathetic) seeking a start in locating CAI information sources and identifying procedural models. Computer-based learning is inventorised in the book by discipline. Procedures for development are analysed, on the basis of the experiences reported in the fourteen case studies which are presented in short for illustration.

The headings under which they discuss the factors determining development are more realistic than the three identified by Anastasio and Morgan (educational, economic, technical). Seidel's are as follows:

1. organisation and mode of finance
2. systematic procedure of course development
3. composition of research and development teams

Points that they make under these groupings are taken up below, under the inventorization of current issues.

Comprehensive though it claims to be, and rich in haphazardly selected practical detail as it is, the book does a disservice to the audience "ranging from educational philosophers, to administrators, teachers and publishers" (p.vii) that they address by the superficiality of their treatment of the fundamental issues. For example, they devote some four pages to the LOGO system, briefly acknowledging that this had been developed under the leadership of Seymour Papert at the MIT Artificial Intelligence Laboratory. The whole rationale of work in Artificial Intelligence - artificial intelligence and the representation of knowledge, its implications for our understanding of perception and cognitive development, its potential for influencing classroom practice - is dismissed in one sentence, which seems to refer only to that aspect listed last, classroom practice.

"There are many questions and hypotheses about the nature of the skills being learned by the student using the system, the relationship of these skills to existing and future mathematics curricula, the longterm effects on problem-solving issues." (op.cit.page 72)

The unwary reader would likely miss the fundamental importance of A.I. in this summary sentence, and there is little in the list of references that would later lead him to supplement this presentation.

An exhaustive review of the whole field of computer-based education systems would be inappropriate here, although a summary for the benefit of the general reader now follows.

Chapter 2

THE ORIGINS AND CONTRIBUTORY SOURCES OF COMPUTER-BASED INSTRUCTIONAL SYSTEMS

Computer technology - the development of time sharing, mini-computers, cheaper teleprocessing, high level computer languages and the like - have made interactive computing and computer-based learning a practical possibility. In fact, the potential offered by computer technology has greatly exceeded what in practice is achieved, and continues to do so. Thus the reasons why some particular lines of development have been followed in preference to others must be sought elsewhere.

"Computer-based instructional systems" has been used in an attempt to find an acceptable, all-embracing term. Computer assisted learning, computer assisted instruction, computer based learning, computer managed instruction and so on and so forth are overlapping, but not synonymous terms. Their multiplicity, and the ferocity with which some are adhered to and others rejected, are indicative not only of the diversity of the applications of computers in learning, but, more importantly, of the fundamental differences in the underlying philosophy of various groups of workers. The causes of these differences are to be found in the multiplicity of sources which have contributed to the development of work in the last decade or so. Five of these sources are considered to have overriding importance. These are, firstly, general developments in the field of educational technology; secondly, growing sophistication in educational measurement and testing, which also derives from and itself feeds the first source identified - educational technology; thirdly, military training and its influence in other vocational areas, such as industrial and medical training; and fourthly, the growing number of subject areas where content and method is inseparable from computers. The fifth source, concerning fundamental research on the representation of knowledge and our understanding of cognitive processes, stands somewhat apart at present, and although, as will be seen below, workers in this area seem to consider themselves isolated, under-appreciated and at a disadvantage when seeking research funding, their influence goes well beyond their own immediate objectives. These five influences correspond more or less to different schools or stages of development in computer-based learning, which will now be considered, in the following order:

1. educational technology and "classical" CAI
2. artificial intelligence
3. adjunct use of the computer in computer-linked subjects
4. knowledge-based systems in the "soft" sciences
5. military and vocational training
6. testing, and computer-managed instruction

At the end of this chapter, on page 27, there is a summary table which classifies these modes within CAI, CMI and research tool, and subdivisions within these. It is hoped that equal attention at this stage will be given to all of them.

It is the position of this report that a computer-based learning system ought only to be established after due consideration of all of these modes, and it should be seen to relate to each one. The evidence of this survey, supported by analysis of the literature, suggests that this has hardly, if ever, been done.

Should it not be done, the rationalization for a particular omission ought to be made explicit, and the preference for a particular emphasis argued, with less dependance than heretofore on personal whim and haphazard choice.

It is recognised that a project must start somewhere. It will be seen in the reported evidence that there is a likelihood that, having started, projects just grow, and that initial assumptions and choices may go unchecked and unevaluated. Thus the barriers between groups of workers and computer-based systems persist, and the benefits of cross-fertilisation that might produce some hybrid vigour, or at least permit an overall consensus, lay out of reach.

2.1 Educational technology and "classical" computer-assisted instruction

Educational technology, one of the early sources of development in CAI, is itself eclectic in origin. It draws on programmed instruction, task analysis, educational television and other audio-visual media, and on systems development. Programmed instruction and educational technology were both terms which had not become crystallised at the time CAI was beginning in the 60's.
Most would now agree that educational technology is concerned with the means of achieving educational goals. Programmed instruction need not necessarily be more restrictive in its meaning, other than in the scope of hardware entailed. For those who came to CAI through educational technology, the conception of the computer was as a super-adaptive teaching machine. For example, in Computers for Education (NCET 1969) one reads:

"there is no real difference in kind between programmed learning and computer-based learning".

(This was an important background paper marking a landmark in the development of computers in education in U.K. and is referred to in that section.)

The superiority of the computer was to be found in the possibility of permitting free responses from students, which, through being independent of particular forms of words, would demonstrate higher levels of understanding. Equally, possibly more importantly, the computer's capability for dealing with free responses would permit the identification of misconceptions and reveal lack of understanding that required individual remedial treatment.
Many present projects are still generally in line with this approach, even though many are at pains to dissociate themselves from programmed instruction. They do so frequently, however, in a manner that betrays their inheritance. In their PLANIT manual, Bennick and Frye (1970), (pp II 3, II 4) write:

"Early CAI too often consisted of the implementation on CAI systems of strictly programmed instruction text-like material..... At its best CAI should be viewed as a new teaching method, not as an improvement of an old one"

and I 10:

"A PLANIT frame is rather unlike a frame of the kind typically found in programmed instruction booklets, since a single PLANIT frame may contain textual material, anticipated answers, performance feedback, statements that perform a calculation etc.".

With the exception of the last, so can, and does, a good programmed text.

The PLANIT teaching frames, subdivided into questions and multiple choice frames are typically programmed instruction of the kind that presents a section of teaching text, sets either an open or multiple choice question to which the student must respond, and provides feedback to the student. The computer then displays another frame of text. The advantage of the computer is that feedback and the choice of the following frame can depend on the student's response. Bennick and Frye list the advantages of CAI as follows (II 4):

"*(1) flexible feedback to students; (2) improved automatic response evaluation; (3) increased ability to adapt instruction to the student; (4) high-speed calculation; (5) rapid and selective retrieval of information; (6) automatic management of performance data; and, (7) a variety of instructional options.*"

However true these may be, they do not constitute a difference in kind between CAI and programmed instruction.
Bennick and Frye themselves go on to say:

"As with conventional programmed instruction, CAI requires active student participation, can provide immediate feedback, can allow students to proceed at their own pace (but can also pace the students), and can test for mastery."

PLANIT has been taken here as an example, but while other author-languages show less similarity to the usual programmed instruction format, the general characteristics of classical CAI is text, followed by question, followed by feedback and so on.

2.2 Artificial Intelligence

A second source of inspiration and development in the use of computers in education has been from the side of artificial intelligence (which is concerned with modelling the representation of knowledge, and the way that it is used).
Alarmed by the lack of success achieved to date in machine translation of natural languages, workers in this field have drawn attention to the dangers implicit in proceeding with what they refer to as "classical" CAI (as it has also here been described), before fundamental problems are further researched. Carbonell summarizes the inadequacies of "classical" CAI as follows:

"The student has little or no initiative; he cannot use natural language in his responses, and systems usually look fairly rigid to him. The teacher has a considerable burden in the preparation of questions, answers, keywords and branching. From a systems point of view, the system controls the student but is in turn tightly ad hoc programmed by the teacher; the system has no real initiative or decision power of its own; and, of course, it has no real 'knowledge'."

Longuet Higgins (1971) is typical of the Artificial Intelligence group in his criticism of CAI:

(1) teaching is an "intelligent" process and to claim that computers could in any real sense teach was misleading;

(2) that using computers for pre-stored material, that is, computerized programmed learning, combined inordinate expense with a very superficial philosophy of education.

(Quoted in: Annett, 1976)

An "intelligent" CAI system is one that can understand and be sensitive to what an individual student does.

Attempts to make computer programs more "intelligent" require the replacement of following specific routes through a pre-stored program, as described in the preceding section, by computer generation of teaching material while the student is at the terminal.

The program producing such material is referred to as a "generative" program. It can be run repeatedly by a student, and it will present him with an appropriate, different learning situation every time he does so.

Such a program is particularly useful in problem solving, where a student is called upon to supply and try out his own possible solutions. The program can 'reason' about the student's responses, and provide him with guidance. Artificial Intelligence provides the know-how that permits this, since it is the study of intelligent behaviour, that is, the understanding of it, its control and its modelling through computer simulation.

Papert (1973) describes Artificial Intelligence as 'cognitive engineering'. The approach of workers in this field and their conception of an adequate 'philosophy' of education can best be illustrated by one of Papert's LOGO experiments. (Papert & Solomon, 1972).

Children can write experiments in LOGO, a simple programming language that will operate a mechanical turtle.
The state of the turtle at any time is described in terms of (1) its position and (2) its direction. To move it forward, a child needs to type FORWARD followed by a number indicating the desired number of 'steps'. To change direction, he types LEFT (or RIGHT) and the desired rotation in degrees. So then, to move the turtle over a triangular path, he types:

```
TO   TRI
1.   FORWARD 150
2.   LEFT    120
3    TRI
END
```

In addition to FORWARD and LEFT, there are 3 other commands:

1. The command TO indicates that a procedure is being defined.
2. After END is typed, that procedure is followed.
3. The use of the command TRI makes the program recursive.

It can be seen how the essence of the approach lies in the manner with which a child can approach such a problem, and deal with his mistakes. He makes a guess at an appropriate procedure, sets it up and tries it out.

Suppose that in an early attempt he types 60 degrees instead of 120 - a very likely error. The turtle describes a hexagonal path instead of a triangular one. The child can see the results of his error, can identify it as the amount of rotation he specified in line 2 and he can try again.

Papert and his co-workers contrast this approach with the usual teacher-oriented classroom, where such a mistake would be an unprofitable experience. They underline the importance of emphasising 'process' rather than 'product' in education, such as has been pointed out elsewhere(e.g. by Bruner in 'Toward a Theory of Instruction', 1966).

As they point out, an early attempt in any worthwhile problem solving activity is likely to have a 'bug', and to 'debug' is an essential strategy to learn; the 'successful' school child can be differentiated from the generally 'unsuccessful' child through having developed successful problem solving strategies.

For all their scorn for traditional teaching in general, and for traditional CAI in particular, it is as yet far from evident that proponents of LOGO type approaches have in fact produced any enhancement in the quality of children's thinking. Camstra (1976b)suggests that cost-effectiveness will only be achieved this way, however, and that it is unlikely to be achieved through classical CAI, or traditional programs. Frames in a classical CAI program are sequenced so that they are unlikely to be re-used by the student working through the program as it is presented to him. An other can either give the learner freedom to compose his own answer in each frame, and the greater that freedom, the more time and effort he will have to invest in programming the answer-accepting routine of each separate unit. Or, he can restrict that freedom, in which case he reduces the program to something that hardly justifies the expense of computer presentation. Neither choice is likely to lead to cost-effectiveness.

On the other hand, the investment of such skill and care in a generative program that will be reiterated is clearly more likely to be worth-while.
Two words of caution would seem to be necessary. The importance of avoiding errors in learning is a controversial topic, which has been summarized elsewhere (Hawkins, 1972). Generally, it would seem that nothing succeeds like success, and a generative computer program needs to be able to draw upon some supplementary facility that will provide whatever support is necessary to achieve it.

Secondly, it will be necessary to improve the facility of working in natural language if this approach is to be successful. The computer program must be capable of generating natural language as well as understanding it. Eventually, it will have to do this in a reasonably short time. These tasks, interpretative and generative, require knowledge of all the relevant concepts in the real world - and that involves a vast amount of information to store and organise. Some success has been achieved to date in which the 'world' to which the language refers is restricted. The world in Winograd's (1971) program, for example, is a table top and the geometrical relationships between 10 3-dimensional wooden blocks and that table top. Schank's (1975) system can describe what happened in a restaurant.

As would be expected, the application of these ideas to actual educational programs is, to date, limited. One of the first was Carbonell's (1970) SCHOLAR.
The program drew on a data base of geographical facts about industries, populations, capitals and so on. It would interpret a restricted English language input, and generate responses and could thus check unanticipated answers to questions or freely generated questions against the data-bank. Recent developments have increased the inferential power of the system (Collins, 1976) but the fact that in its early stages it was restricted to factual information was a serious limitation. At tertiary level, techniques and processes dominate. In order to incorporate these, intelligent CAI and simulations are brought together, as in the SOPHIE system (Brown, Burton, Bell and Bobrow, 1974). A student has to identify and remedy faults in a power supply. He can call for voltage readings, replace components and conduct an intelligent dialogue. Other systems in elementary logic (Goldberg, 1973) and in computer languages (Barr, Beard and Atkinson, 1975), have been developed at Stanford. The construction of the relevant semantic knowledge store is made possible in all of these fields because, although much larger in scope than Papert's turtle and Winograd's table top, they still refer to what Carbonell and Collins (1974) call 'closed worlds'. That is, they require no 'referent' that points outside that world. At the present level of working in natural language, this is necessary.
Unfortunately most university level subject matter cannot be represented by closed worlds. Work is proceeding in a number of centres to build systems that will support a wider ranging didactic dialogue. Howe (1975, pp 306, 307) describes the approach undertaken by colleagues in Edinburgh:

"- *the 'world' is limited to that which can be described in a single sentence, including some of its more obvious implications;*

- *the reference sentence and its possible paraphrase are constructed from a limited vocabulary (avoiding ambiguity); and*

- *the definitions of the words in the vocabulary include only simple commonplace concepts. Taken together these definitions constitute the total knowledge which the system can have of its 'world'.*

Noble has implemented part of the system with a very small repertoire of words in the dictionary. It performs reasonably, if very slowly. Given two sentences S1 and S2 the system first analysed each sentence and constructs a semantic representation of each. The second stage in the process is the comparison of the semantic models. The comparison is two way: S1 entails S2 and S2 entails S1. Only if both tests succeed is S1 declared to be synonymous with S2. At present the program examines S1 and S2 for similar entities, similar time relationships and similar causal structure."

Breuker and Camstra (1976) are proceeding similarly at Amsterdam. They describe a system which includes, firstly, a SEMANTIC PARSER, which abstracts an interpretation from input sentences on which the rest of the system can act. The parser relates input words with internal representations stored in the LEXICON.

The lexicon contains the meanings of words and refers to the representation of subject matter and the simulated world. These form the knowledge base on which the system operates. The matter they have chosen to work with is experimental methodology in the social sciences. A combination of tutorial and simulation is incorporated, along the lines of that featured in the SOPHIE system. Breuker and Camstra (1976) acknowledge the difficulty of the undertaking, which is planned to be operational on an experimental basis by 1982, and which they consider is concurrent with other developments that they list (e.g. Brown, 1975).

2.3. Adjunct use of the computer in computer-linked subjects

Thus, while there are negative comments on traditional CAI (and on traditional teaching, for that matter) from the A.I. camp, there is as yet little with a theoretical basis with which it can be replaced, as the third group of workers in the general field of computer based learning systems are not slow to point out. These are the university teachers in those subjects where the use of the computer is now inevitable, in maths, engineering and the sciences. Smith (1975) for example states that all institutes of higher education are engaged in some form of CAI activity in their engineering courses. Many of the engineering processes which have to be considered in the undergraduate curriculum are highly complex. Many of the mathematical models that simulate them can only be treated by computer-based numerical methods. In this situation the teacher's choice is between bare presentation of results from computer analysis, or participation by students in computer-based activity. In science subjects, too, the edges between such inevitable activities as calculating, modelling, simulating, problem-solving, and computer-based learning systems become increasingly blurred, so that CAI work is entering these subjects not so much from a primary concern to improve learning, but because some of the subject matter and some of the processes that have to be learnt are becoming inseparable from computing, as the following quotation makes clear:

"The computational approach to the study of applied mathematics has been found to be of great educational value. A large part of applied mathematics could be described as model building; mathematical equations are set up to represent a system whose behaviour is to be modelled, and it is the mathematician's job to discover the consequences of the choice of equations. Since this choice is dependent on the assumptions made about the physical laws supposed to govern the system itself, the mathematical consequences will provide data on the correctness or limitations of those assumptions, and allow an improved model to be constructed. The use of the computer can often simplify the process of mathematical investigation, allowing greater emphasis to be placed on the model-building process itself. Once a computer program has been written by the student, and this is usually a fairly simple task for most of the models or problems studied, various numerical parameters can be changed at will and the effect of doing so quickly observed. The equations themselves can also often be changed easily. If the programming is too difficult, a prewritten program can be provided, but we have always felt that, where practicable, students should write their own programs. The reason for this is that before a program can be written, the essential features of the problem must be understood, and in order to check the program, the student must look hard at his results to see if they are reasonable in qualitative terms. This contrasts with the analytic approach where the mathematical form of solution can sometimes disguise the real nature of the problem." (Harding, 1975, page 187)

In fields such as these, faculty members have proceeded with a minimum of pedagogical structure. Among the PLATO system developers, Sherwood writes, for example:

"most ..... are engineers or physicists, although the head of system software is a biologist. It is noteworthy that none of the developers come from education (although most have taught), nor from computer science (although they have had extensive experience of using computers in their research). These people (including the biologist) come from experimental science and engineering and not theory"

(response to questionnaire, see further below)

Likewise, in the British National Development Programme in CAL (NDPCAL), Annett (1975) reports their "lack of enthusiasm for basing the national programme on the results of basic research into learning theory or behavioral patterns".
And Hooper himself, the project director, writes "CAL must find its guiding inspiration from the discipline and from the teacher, not from the computer scientist and technologist".
Most of the NDP project directors are subject specialists from the range of subjects that Sherwood lists (chemists, engineers etc.), who also tend to rely on their own ideas and experiences of teaching and learning.

Annett notes, however, that although the NDPCAL has no built-in research policy, a number of problems have emerged which require reference to many literature sources and relevant research-based expertise. Thus, events seem likely to turn full circle. Having rejected an approach where basic research has led to applications, applications have led to the identification of research problems. People working with CAL are beginning to seek methods to demonstrate that it is effective, and determine how research can lead to further understanding of the learning processes that they, from their pragmatic approach, are trying to manipulate.

2.4. Knowledge-based systems in the 'soft' sciences

There is a link between the uses of the computer in facilitating learning in the hard sciences already making extensive use of computers, and the knowledge-based systems refered to in the section on Artificial Intelligence. In the previous section, it was stated that where computers are used to generate results from experimental data, it is often a short step to simulate the processes that generate that data, and to control the important parameters concerned so that their effects can be investigated and demonstrated. In the 'softer' sciences such as geography, economics and business studies a similar development is taking place. In these subjects the development of adequate models requires the accumulation and accessibility of a large amount of data. This takes time, money and resources to acquire on a scale that is not usually available to students.
But an adequately established and maintained data-bank can save countless field trips. A real or simulated population to study, always at hand, and ready to provide the material for hypothesis testing and model building, provides the 'soft' sciences with a continuously available laboratory, such as has always been available in the hard sciences.

A pioneering effort in this work is the project IMPRESS (Meyers 1970), the key features of which are:

1) accessibility of a variety of large social data bases
2) availability of a wide selection of statistical and data transformational techniques, and
3) relatively uncomplicated procedures for system use.

2.5. Influence from Military, Vocational and Industrial Training

In the aspects of computer based learning described so far, it is evident that there is doubt about its purposes and advantages. It has frequently been called a solution in search of a problem. In this and the following section on measurement and testing of its influence, the purposes and advantages of computer based instruction are much more clear cut.

Military, medical and industrial training often demands learning situations that are impossible to provide realistically, either because they are too expensive, impossible for ethical reasons, too distant, or too infrequent. A computer-based facility can and is frequently used to overcome this. In order to do so, the facility is called upon to behave like something else, or as closely to it as possible according to some idealized model, in other words, as a simulator. Strict training routines in tertiary education are rare, but one area where the use of computer assisted learning in this predominantly simulation mode can be justified with this level of clarity is in clinical decision making. Taylor (1975) puts forward the following reasons to support its use:

"*a) the student is able to acquire individual experience of a systematic approach to clinical decision making*

b) a wide variety of cases can be presented for the student's assessment without being dependent on the availability of suitable cases in the wards

c) the patient is not exposed to unnecessary disturbance while students gain experience in making decisions and following the consequences of such decisions

d) it can be assessed comprehensively in a short time span

e) limited features of a patient's problem can be tackled without extraneous details

The relatively high frequency of computer based learning systems in medical faculties is frequently commented upon, and sometimes attributed to a more ready availability of research funding particularly in the United States. While this may be so, it is suggested that the unassailability of the advantages that Taylor has listed, and the comparative clarity of the learning task, are more decisive factors.

Duncan (1976) has described how computer-based instruction is similarly especially suitable for dental education. Simulation of student-patient encounters provide opportunities for diagnostic and other problem-solving exercises. Computer graphics can teach growth and development of the teeth. A student can be shown the outcome of orthodontic treatment that he prescribes. In restorative dentistry, the effect of years of wear on a restored tooth surface can be demonstrated in seconds.

It will be evident that many of these or similar points will be of relevance in the subject areas listed in the previous section, in the sciences and maths and engineering, where simulation and modelling will be important modes. Smith and Sherwood (1976) point out that, since science is based on the results of experiments, students need to learn to design experiments. Laboratory conditions demand only too frequently that students follow set routines, which they play no part in establishing. Time, equipment, their own limited technique, makes real-time practice in experimental design impossible. They describe how with computer simulation students can design experiments in chemistry, select the compounds and reaction conditions, collect the experimental data, do the mathematical analysis, and outline the conclusions. This can be done speedily, because the computer can rapidly calculate the outcome of experiments of a given type from algorithms built into the system.
Besides the advantage of speed, experiments can be simulated that would be beyond the technical skills of the students or facilities of their laboratory. There is a difference between the dental (or medical) situation and other university doctrines, in that it is at once agreed and recognized that, in dentistry, there are thousands of procedures which the student must learn to carry out meticulously. (Duncan 1976). The learning experiences cannot be restricted to a selection of experiments, with the justification that the working situations in which students later find themselves will differ widely from each other, are difficult to predict, that this will be recognized by future employers and further on-the-job training and experience will be available. The dentist must be prepared to deal with everything that comes. The teaching clinic has to maintain a post of thousands of patients and carefully record each student's clinical experience. Also, patients must be protected. The logistics of simultaneously providing clinical training and treatment call for computer assistance, and the appropriateness of computer-managed instruction is clear.

2.6. Testing, and Computer Managed Instruction

The purposes and possible advantages of testing students by computer, which would facilitate the installation of mastery learning and individualization of instruction through computer-managed instruction, are also clear cut. In a situation where student numbers are failing to rise, or are not permitted to do so to any great extent, and where there is even unemployment and general insecurity among teachers at all levels, it would be nonsense to claim that computer based instruction should be developed in order to cope with ever increasing student numbers in a climate of teacher shortage. When one considers how much effort is required to develop a traditional CAI teaching package of just 2 hours duration, and further considers what the involvement would become should all students of a university receive 2 hours of instruction through CAI each week, it is evident that consideration of the computer in terms of teacher replacement is quite unrealistic, at the present stage of development in any case. The computer, then, is sought to support and supplement the traditional teacher

Although at the university level teaching is rated well below research in importance if not in interest, teaching is not usually considered a burden. The tasks associated with it, both administrative and evaluative, most certainly are, however. Teachers would unanimously welcome the chance to off-load these. At the present time, pressures are to increase these even further.

Student demand for increased diversity makes administration more complex, and modularisation, mastery learning, and the individualization of instruction call for more frequent testing and feedback to students.

One institute that has been ready to anticipate and react to these pressures is the U.K.'s Open University, which processes all the straightforward multiple choice assignments by computer, now amounting to over ½ million computer-marked assignments a year. At Ohio University Medical School, incoming students can choose between an independent study program (ISP) and a traditional curriculum for the first two years of the course. The computer element of the system, TES (Tutorial Evaluation System) "helps a student achieve short-term goals by giving him some idea of where he is going".(Ingellshore,1970;Griesen,1973). Having found out where he is going, TES provides him with remedial materials, if he needs them. This is, in fact, a brief description of mastery learning, and of computer-managed instruction.

Bloom and his co-workers have demonstrated that the efficiency of the instructional process can be greatly improved (Block et al, 1971), through the application of techniques associated with their names. By breaking the student's work into small units, providing practice and feedback within each unit, testing his achievement of the unit's objectives on his completion of it, preventing him from leaving that unit before demonstrating his mastery of its objectives.

Computer-managed instruction seeks further to individualize instruction by routing the student through his course of study on the basis of his achievement, individual characteristics and interests. CAI was one of the first applications of the computer in education to make an impact. The last few years have seen little change in this field, although the potential advantages are acknowledged. This is probably because further development in CMI will require large scale organizational changes, which are slow to materialize.

The forms of computer-based learning systems that have been described are summarized in Table 2.1. The CAI aspects of computer-based learning are divided into a) the tutor, or teaching machine mode, and b) the laboratory mode. The management aspects of computer-based learning, CMI, have been divided into a) straightforward automation of existing administrative procedures, recording student performance on completion of their course work, and b) the prescriptive use of CMI, providing feedback on which guidance can be based during learning.

The final category consists of the computer as a research instrument in cognitive science.

TABLE 2.1. COMPUTER BASED LEARNING SYSTEMS

	ROLE	TITLE	SOURCE	EXPLANATION
CAI	Teaching machine	"Classical" CAI	Programmed learning, educational technology	Text followed by question, to which student responds and receives feedback
	Laboratory	Adjunct use of computer in 'hard' sciences Knowledge-based systems in the 'soft' sciences	Availability and use in computer-linked subjects Attempts to achieve the advantages of laboratory-based subjects in other subjects.	Simulation Modelling Problem solving
CMI	Testing	Use of computer in administration of testing procedures	Use of standardised objective tests	Test making, record keeping test-item banking test production
	Prescription	Individualized Instruction	Mastery learning, requirements of formative as well as summative evaluation and rapid feedback	Routes student through study materials on the basis of his achievement and individual characteristics
Research Tool	Research instrument in the cognitive sciences	Artificial intelligence	Artifical intelligence Machine translation and cognitive psychology	Attempts to achieve a precise understanding of the mechanisms capable of mediating intelligent behaviour by specifying such mechanisms in formal terms

Chapter 3

THE ISSUES OF THE QUESTIONNAIRE

According to Anastasio and Morgan, the factors inhibiting the widespread use of computers in education had three principal dimensions - educational, economic and technical. These dimensions can be seen in the six categories in which they grouped participants' opinions:

1. Production and distribution of instruction materials
2. Demonstration of the effectiveness of CAI
3. Need for fundamental educational and psychological research
4. The educational system and the teacher's place within it
5. Cost
6. Technical research and development

As they stand, none of these seems to be specific to CAI. The use of standardized achievement tests, educational television and whatever have had to contend with these factors. Why is CAI apparently so singularly unsuccessful in doing so?
Bullock (1976) considers just some of these of overriding importance. He writes:

"until computer facilities are routinely available in training environments and the cost effectiveness can be shown to compare favourably with..... alternatively instructional delivery systems .., CAI is likely to continue mainly as a government subsidized R & D activity!"

But, in tertiary education, computer facilities are routinely available. Many cost-effectiveness studies, in particular those from military training, have been favourable.

Siedel and his co-workers (Hunter et al, 1975) see it rather differently, in the isolation of CAI workers, producing materials solely for use in their own environments. This is the present situation for 95% of the materials being written today, written, that is to say, without regard for what has already been developed, or is being developed, elsewhere. Their point of view is summarized as follows:

1. There is a need for computer-based materials, but it is at present only being satisfied through local efforts;

2. The costs of continual re-creation and re-invention of applications, techniques and materials is prohibitive;

3. The traditional mechanisms of dissemination of curricular materials are inadequate for CAI;

4. A massive effort in promoting the computing literacy of educators is required;

There are flourishing projects, several of which are extremely well-known, such as TICCIT and PLATO, firmly established, and expanding their activities. Some of these, we know, are linked through networks, based on either discipline or geography. Thus, there seems to be some truth in Siedel's first three points; success in CAI is associated with overcoming the economies of scale and the problems of dissemination and transfer. Their fourth point seems also likely to be valid.

These four points do not help us to explain further what makes success and failure so specific, and so local. In the overview of computer based learning in U.K. in Chapter 4, the importance attached to institutionalization by Annett and Hooper is discussed. It is considered here that they seem to come to the heart of the matter, although their conception of institutionalization is, for present purposes, inadequate. They differentiate between the 'soft' money that comes from government and other outside funding agencies; and 'hard' money, which has to come from the budget of the institute hosting CAI activities itself. 'Institutionalization' in terms of matched funding from the host institute has been insisted upon in the U.K. National Development program in computer based learning, and support from the host institute is considered an important factor in their evaluation procedures.

Surely, institutionalization in terms of matched funding is only a symptom that certain factors necessary for the health of CAI are present. It should not be mistaken for the reality. One can say 'hurrah' or 'boo' as may be considered appropriate to a university administration that does, or does not, support computer based learning activity in terms of its budgetary arrangements. It would be more profitable to consider as objectively as possible what would lead them to extend such support. Administrators are concerned with an overall framework. To those competing for funds, this may only seem to imply that support given in one area is necessarily at the expense of another.

It is suggested that that framework can best be considered in terms of balance and compatability. To succeed in obtaining support, the resources required for one particular development ought not to seem out of line in comparison with similar projects with similar objectives. Further, a project that is likely to feed other concurrent developments is more likely to prosper than one that is isolated.

Three general areas of development can be identified which could benefit from and host computer-based learning activites, and these are:

1. curriculum development

2. exploitation of audio-visual aids and self-instructional materials

3. organizational change associated with the individualization of instruction

Several respondents (Lower of Simon Fraser, Canada, to quote one) have pointed out the inutility of attempting to develop computer-based learning without linking it to other, contemporary reforms.

The place of the computer in these three areas needs careful identification. Where there is curriculum development, it would be an unusually enthusiastic supporter of CAI who would contemplate the total analysis and revision of the curriculum in the detail required for computer presentation. Rather, a possible enrichment, or solution of a bottleneck, whose effects will spread over into the total course activity, needs to be sought.

In terms of educational technology, the computer needs to be considered as just one among many instructional media, for all of which instructional materials are developed and validated according to the approach, principles and techniques that have been developed now in this field. Where these are not applied, and the more usual varieties of instructional media are not appropriately or fully exploited, it is unlikely that they will be applied to computers in isolation, or that these will be well integrated into a full range of educational activities.

Organizational structure refers to the changes consequent upon the development of new instructional techniques. Of major importance at the present time are mastery learning, modularisation of courses, individualization of instruction and the development of multi-disciplinary courses.

Improving the efficiency of instruction may be sought in terms of improving the likelihood of success of students having the required course prerequisites. It can also be found in economies of scale. Departments with similar problems - science and engineering departments whose students are failing to master the mathematics required for example - can co-operate in developing materials which all can use. Departments having to run courses with large student numbers with insufficient faculty to provide individual practice and feedback can develop self-administered tests and exercises. In each case, these could well be computer-based learning activities.

These three types of development, curriculum development, educational technology, organizational change, may occur in isolation, or together. It will be a very static educational environment in which none of these can be found. The extent to which these developments have been located, and computer developments integrated with them, has been considered here as the most appropriate measure of 'institutionalization'.

Then, having established itself in an environment conducive to growth, a project needs to develop through two distinct processes - the process of systems development, and the process of materials development.

A copy of the questionnaire is attached, in the Appendix,in which these issues can be seen to be reflected in the questions that have been posed. The information sought has been set into a number of categories which are summarized below, with the points incorporated into each.

I. The general development and scale of work of the projects

The origins, organization and accessibility of projects.
The composition of project teams.
Obstacles to the creation, dissemination and adoption of CAI materials that have actually been encountered.
Use of systematic procedures for selecting subject areas.
Developing course materials and evaluating them.
Materials available, and total student-terminal hours.
Amount of inter-institutional cooperation.
Factors considered to have contributed to success.

II. Purposes of the project or unit

Objectives of projects.
Ranked order of suggested reasons for developing computer based learning activities.

III. Technical aspects

(The cooperation foreseen in analysing this section of the report has not been forthcoming. Should there be sufficient demand, information from this section can be published later as a separate appendix.)

IV. Training of non-specialists and consulting services

Initial courses in computer languages.
Initial courses in instructional design.
Informal advice and further consultancy.

V. Courseware development

Criteria for topic selection.
Process of package development and evaluation.

VI. The future

Developments envisaged in configuration, terminals, system software, lesson style, development and interchange.
Identification with the future of CAI.

Thus the factors described - achievement of economies of scale, institutionalization in terms of integration with ongoing developments, the development of materials - have been investigated in terms of the current situation and anticipated changes.

The format of the questionnaire is that of open questions, followed by suggested possible replies, with space for comment and alternatives. A few respondents have, with some justice, expressed their displeasure at being asked to complete such a lengthy questionnaire, and a number of these have asked why it was not designed so that answers could be checked rather then spontaneously produced. In fact, some respondents did treat the questions in this way, checking alternatives without comment, But the fact that so many other participants took the trouble to supply a wealth of specific, important detail, which would have been lost had the format been changed to just the checking of alternatives, leaves the author apologetic but unrepentant. The spontaneous comment carries so much more conviction than the checked item. This spontaneous comment and fine detail has been fascinating to read and most useful for the preparation of a report further to the recommended development of computer based learning in Utrecht, and we are indeed grateful for the generous response that has been obtained.

The opinion has been expressed that it is not yet possible to reach a consensus view. But with so many questionnaires to summarize, a case study approach has also not been feasible. In the section summarizing the analysis of the questionnaires, the responses to the questions have been generalized wherever possible, with many specific comments reported in addition, attributed where this is of importance and not likely to embarrass the respondent concerned.

Every effort has been made to reflect all opinions expressed, although at times in a shared paraphrase or a short summary, and it is hoped that no one who responded to the questionnaire will feel that important comment has been omitted or distorted in the process. The feeling of'this is where it's at', with frank comment on recognizable, real situations by recognizable, real personalities, is unfortunately difficult to convey in such a document as this. It is hoped that this summary will nevertheless be of use outside the immediate purpose it was designed to serve.

Chapter 4

COMPUTER-BASED LEARNING IN U.K.

The official history of computer-based learning in U.K. goes back to 1967, when the National Council of Educational Technology (itself established in 1966) set up a working party under the chairmanship of Professor J. Black, with the following terms of reference, according to their first working paper:

1) *to investigate the potential role of the computer as a component of educational and training systems in the United Kingdom, taking into account as necessary experience and trends in other countries;*

2) *to outline a systematic programme of applied research and development which it would be desirable to encourage in this country, aimed at exploiting the computer to the best advantage in education and training.*

(NCET, 1969a, p.2)

The working paper quoted above was followed by two more from the NCET - a feasibility study and a program proposal (NCET 1969 b. and c.). After an intervening period of general discussion between the DES and other interested parties, in May 1972, the Government gave its official approval and support to a "National Development Programme in Computer Assisted Learning (NDPCAL)", with funding commencing in January 1973. The projects listed in the NCET proposal referred to above - 'Computer based learning - a programme for action' (NCET 1969b), were modified as a result of these discussions, which (according to Annett) were influenced by the circulation of the Lighthill Report on Artificial Intelligence, a report that was not generally available until 1973 (Annett 1976).

The revised program of the NDPCAL was set out in 'Initial Guidelines' (reported in Hooper 1975). The future of Artificial Intelligence and other fundamental research was considered to be in doubt. Thus the emphasis of the project was placed on design studies and evaluation, within the subject areas of mathematics and science in schools and colleges, and mathematics, science and medicine at university level. (They also included the training of technicians in the armed services, and Industrial Training, which are outside the range of interest of this report).
An interim report of the first two years of the National Programme has been published by the Director (Hooper 1975). He divides this period into four phases; first, exploration; then the setting up, consolidation and lastly (at this stage) the mid-term evaluation of projects.

The program had as its initial aim:

- *to develop and secure the assimilation of computer-assisted and computer-managed learning on a regular institutional basis, at reasonable cost* -.

This important principle was based, the author writes, on his personal observation of the American experience of educational technology (Hooper, 1975, p. 17). An educational innovation tends to last as long as the 'soft' money lasts - but directly an institution has to fund the project itself (from 'hard' money), then the innovation is likely to be discontinued.

One of the frequently quoted examples of this phenomenon is the CAI Russian course at Stanford. It is a situation which occurs only too frequently, and will no doubt sound familiar to the reader. It indicates from another vie. -point the over-simplification of Anastasio's innovation model, his answer to the deadlock referred to in Chapter 1 (p. 11). Although successful innovation depends on the availability of good materials, the production of good materials, whether or not accompanied by data from control group experiments, does not necessarily lead to innovation.

Thus, the NDPCAL has 'matched funding' as a requirement of all institutions hosting CAI projects. Project directors have thus been obliged to convince their local decision makers and the directorate of the NDPCAL program in equal measure that their proposals are worth-while. Local institutional commitment is an important aspect of project evaluation.

The second important characteristic of the NDPCAL is that it is a 'co-operative' program. Hooper contrasts two simplified models of multi-institutional research and development - the centralized model and the local model. With the centralized model, a national team is recruited by taking people out of their usual working situation and putting them together in one host institution. With the local model, grants are awarded to individuals in particular institutions to carry out research and/or development as they see fit, with little national integration or control.

The NDPCAL conforms to neither of these models - partly through design, partly through evolution. Hooper describes it as a 'co-operative program, with decentralized projects and matched funding leading to local involvement, and coordination and diffusion and control of overall costs.' The pattern is not just one of centralization - decentralization, but also one of clusters of cooperating institutional activity expected to be particularly rewarding. The problems of transferability,incompatible hardware, inability to accept another teacher's approach etc. are well documented. Where teachers from different institutions get together and prepare materials jointly from the beginning, these problems are not likely to arise, at least for those involved in their production and development.

It is reported that projects have a 'bilateral' basis, with both sides - local project directorate and NDPCAL directorate - able to exert their point of view. It was noted in the responses to the questionnaire that the NDPCAL projects do, however, have a certain similarity in their approach, and although the project directorate writes that "on occasions, project directors have pointed out that their views must be considered since they are also putting resources into the project" (Hooper 1975, p. 40), it is evident that the opposite has also been the case. The following paragraph indicates how the concept of institutionalization that the NDPCAL directorate arrived at led to a certain element of selectivity in the projects that were fostered and supported.

"Aiming for institutionalisation has, of course, a number of implications for project selection and design. As a result of the aim, the Programme has got directly involved with, for example, university teaching departments and not just educational technology units or computing centres. Two of the tertiary education projects are directed by heads of teaching departments, significantly. The three current schools projects are all based in local education authorities (not universities)."

These first two characteristics of the NDPCAL - matched funding and its cooperative nature - meet with general approval in U.K., although questions have been raised over the authenticity of their origins. There is more division of opinion over the third characteristic which has just been alluded to - the exclusion of psychologists and educational technologists - which is only to be expected, as it is one of exclusion, leading to the non-participation of potentially interested parties.

In order to indicate how this has come about and what its implications are, it is necessary to look at parallel developments in computer-based learning activities in U.K. at that time. At the time of the establishment of NCET's working party under the chairmanship of Prof. Black, the SSRC (the Social Science Research Council) had received its first applications for research funds, and the establishment of three main projects. These were for 'the development and evaluation of a computerized learning system' in the University of Leeds, and an off-line computer-aided learning system for schools in the London Borough of Havering in 1969, followed by a study of computer assisted instruction with young children in 1970, and the development of an 'intelligent teaching system' in 1972, both in the Dept. of Machine Intelligence at Edinburgh. Thus, their implementation pre-dated the establishment of the NDPCAL program. By 1971 all these projects had run into organization or technical difficulties. There were also fundamental differences between the A.I. workers and those in other projects, which led to a confrontation situation in a symposium held at Keele in September 1971, where these groups were all represented, and the proceedings observed by NCET, whose proposals for the NDPCAL were then under discussion. These events were followed by the Lighthill Report referred to, which was critical of A.I.

In the interests of clarification, and to advise the SSRC on the kind of research program that ought to be supported a study visit to the United States by Prof. Annett and D. Sleeman was sponsored, which reported to the SSRC in November 1971. He has summarized their conclusions elsewhere (Annett 1975), where he also describes the chain of events that followed this report, and which are summarized below.

Annett's report was followed by a series of meetings including most of those who had attended the Keele conference, and a series of papers. The first of these identified the different broad classes of research recommended. The first would be concerned with CAI techniques, and would include basic research in areas such as adaptively controlled learning and the nature of 'intelligent' teaching. The second type would be design studies which would take a systems approach to the use of the computer in a given educational situation and would give attention to the educational, technical, economic and organizational factors in that situation.

The third type, to follow the second, would be the setting up and evaluation of one or more CAI systems. The underlying principle leading to the proposition of these three types of research was that evaluation, including educational, economic, technical and social factors, could only be realistically undertaken in a fully established system, as in type three; and that a type three project ought not to be mounted without the parallel background activities of basic research and design studies of types one and two.

The uncertainty referred to earlier led to curtailment of this program, so that the final paper of June 1973 proposed research of the first type in four priority areas; CMI, LOGO and related studies of "teaching children to think", simulation studies, and "learning science".
"Learning science" was to be a multi-disciplinary field involving education, cognitive psychology and artificial intelligence.

The Science Research Council (SRC) also sponsored discussions following the Keele symposium and the Lighthill Report on the importance of 'cognitive science', also an inter-disciplinary area, including A.I., experimental psychology, and also linguistics. The working party included N.S. Sutherland, H.C. Longuet-Higgins and D.E. Broadbent, and reported in February 1973. In their view computer-aided instruction, although useful, cannot realize its full potential without "further advances in our understanding of human cognition and on our ability to write programs that make computers function in an intelligent way .....". In the opinion of the working party "advances in our understanding of our own thought processes are ... initial for improvements in education and training." (Sutherland, 1973).

The early initiatives supported by the SSRC have been allowed to fall behind, and the impact of the SRC supported Cognitive Science is yet to be made. The British scene in computer-based instruction is at the present time largely dominated by the NDPCAL.

In contrast with the SRC and SSRC, the NCET/Ministry of Technology team of seven responsible for the national program in CAL includes no one experienced in research on teaching and learning. As a reaction to the apparently uncoordinated American research, and possibly as a result of the discussions and doubts expressed in U.K. which have been referred to, there was a deliberate exclusion of 'basic' research and (contrary to NCET's 1969 recommendations) a tightly coordinated program, under Government control. Having delayed commencement of their program until 1973, they were able to stand on the shoulders of those who had made a start - an advantage of which, according to Annett, they availed themselves readily. He points out for example, that the principle of 'institutionalization' was first put forward in the Annett/Sleeman Report (1970), before becoming a cornerstone of NCET policy, formulated as late as January 1973 by Hooper's own account (Hooper 1975, p. 17).

Be that as it may, the existing projects of 1973 had only been subject to internal or retrospective external evaluation. Concurrent evaluation in the sense of "how it all happened, warts and all", was built in from the start, and external evaluation got underway in 1974. Evaluation in general is being conducted by the UNCAL team (UNCAL= Understanding Computer Assisted Learning) of the University of East Anglia under the leadership of Barry MacDonald. Their task was not made easier by the lack of specific aims and negative attitude to fundamental research issues, and in order to clarify the role of evaluation the UNCAL team produced a paper which obliged the NDPCAL committee to specify what kinds of information the program ought to be called upon to produce. As a result, the second aim of the project was added to the first in 1974, well after the activities were underway. It reads as follows:

" *1) to make recommendations to appropriate agencies in the public and private sector ..... concerning possible future levels and types of investment in computer-assisted and computer-managed learning in education and training;* "

(Hooper 1975, p. 17)

The products by which the achievement of the first aim (see p. 33) would be judged, would be the number of 'institutionalized' computer-based learning systems.

The products by which the achievement of the belated second aim would be judged, would similarly be the justification of a number of recommendations concerning computer-based learning systems.

To what extent these aims can be met within the framework of the current program is doubtful, and this is possibly recognized by the program directorate, since the products of aim 2 are expected to take the form of a series of reports, published up to about 1975 (Hooper, loc cit). Hence, some continuation of the program without a change of aims is anticipated. As it stands, the first aim, concerning institutionalization, can be met through the case-study developmental approach that has been undertaken. The second, in terms of recommendations, is unlikely to be achieved until the basic questions such as 'can computers teach', 'is CAL cost-effective' are broken down into specific questions and studied in contexts that permit formal experimental design and control of the variables under discussion.

It is evident however from the analysis of the questionnaires that follows that much has been achieved through the NDPCAL projects, and the problems and research needs which they generate are unlikely to escape the attention of the evaluators. The reader who seeks a model for establishing a coordinated program of projects will be prompted from this historical sketch to visualize what might have been, as well as what is, but the possiblity of further development along more rigorous, fundamental lines can also be seen.

Chapter 5

COMPUTER-BASED LEARNING IN U.S.A.

The history of computer based learning in U.S.A. is, basically, the history of computer based learning.

Since the different styles of computer-based learning and their contributory sources have already been surveyed, this chapter will be confined to the following:

- a preliminary statement of the trends in U.S.A. as previously identified, with a brief overview of:
- the major projects in the developmental context that set these trends;
- the multi-institutional projects of present importance.

With the variety and independence of the main centres of development in U.S.A. and the number of alternative funding sources, there is none of the homogeneity of the projects in, for example, the U.K. Such lack of uniformity makes choices in configuration, hardware and software difficult. As these are an important part of the decision-making that will influence the nature and growth of a CAI project, there is a brief summary of some of the areas where there is a conflict of choice.

The comments over the major projects will be brief also, because they already dominate the literature, and further information can be obtained as indicated. Most of those referred to below are included in the responding questionnaires to this enquiry. As would be expected, there were many detailed, forthright contributions of great value. It was notable, however, that there was much independent comment of interest from, at present, lesser known projects, and at times it was possible to see a divergence of opinion between, say, the leading group of a multi-institutional project and a smaller group that had access to it. In order to be able to present all comment frankly, and also not to continue the above mentioned trend by overweighting comments from major projects with authoritative acknowledgment, comments have in general been reported without reference to author; there are occasional references to projects where clarity demands it.

Early trends

The growth of computer-based learning in the 1960's has been summarized by Zinn (1970) and Levien (1972), and the situation as it was in 1970 can be surmised from the proceedings of the IFIP (International Federation for Information Processing) World Conference on Computer Education, held in Amsterdam in 1970. (Scheepmaker and Zinn, 1970). The second IFIP Conference was held in Marseilles in 1975, and the papers given there were broadly representative of the situation in 1975. (Lecarme and Lewis, 1975). The intervening period has been charted for the American scene by the HumRRO project under Seidel. (Hunter et al, 1975). There are also of course many other publications from the projects themselves.

The trends that were emerging in the 1960's have been listed by Levien (1972). A number of those listed would seem to have become even more marked, as for example the following:

- the availability and use of on-line, time-sharing computer systems is growing and establishing the environment for wider use of the computer in education;
- colleges and universities have begun to group themselves into consortia to share computing resources and, increasingly, instructional materials;
- a small number of major projects have evolved as the focuses for extensive programs of interrelated hardware, software and courseware development;
- a large number of small projects have sprung up on a wide variety of campuses to develop computer-based materials for specific courses.

The growth of the major projects

Having commenced in U.S.A., computer-based learning was particularly influenced in its early stages by the contemporary programmed learning and teaching machine movement as developed and promoted there by B.F. Skinner and his colleagues. A second important factor, and a difference from the later developments in Europe, was the involvement of the computer companies themselves, which has in general been sustained. As far back as 1958 there was a demonstration of computer teaching of binary arithmetic at IBM's Research Center. In describing the project, Rath et al (1959) refer to Skinner and Pressey and state one of the aims of their project to be the simulation of a teaching machine. System Development Corporation and Bolt, Beranek and Newman (BB & N), also had demonstration materials, using the computer to present programmed instruction, at about that time.

The PLATO computer system initiated with NSF support in 1960 by Alpert and Bitzer (1970), sited at the University of Illinois, was, in contrast, designed without reference to any particular school of learning. Their goal has been the provision of interactive, self-paced instruction for large numbers of students and the simplification of programming procedures for curriculum authors. It has been an important principle throughout for this project to serve instructional innovation and not to impose it.

A tide of enthusiasm led to the pursuit of computer-based teaching by a number of organizations, so that during the 1960's the early efforts of the computer companies were supplemented by work in the armed services and the universities. This wave of enthusiasm subsided to some extent, so that not all the projects with an early start show a continuous line of development. Many of the leading projects of today do, however, date back to the early and mid 1960's. One of the first of these was at the Stanford Institute for Mathematical Studies in the Social Sciences, in 1963. Their project in reading and basic arithmetic has been followed by equally well known coordinated use of CAI and a language laboratory in a 2 year Russian course, and later work in logic, and so on.

Latest developments were described by Suppes and his colleagues at the second IFIP World Conference, and there is a host of articles available elsewhere.

The materials developed by these two centres have been used extensively in other institutes. That these 'client' institutes are not mere passive recipients, and are often led by project leaders who have entered the field somewhat later and then made an assessment of what is available before attempting to'reinvent the wheel',has been evidenced by some of the replies received. Purdue's Pharmacy School's project is led by Deiss, who writes 'if something like PLATO had not already been available, I would have had to sit down and design something like it .'
And one feels as one reads the rest of his responses to the questionnaire that he very likely would have done. Torr at Gallaudet has the responsibility of a project for the only Liberal Arts College for deaf students, and materials such as the Stanford Russian course along with others from multiple sources have been utilized to provide an extensive service in a short time in an area where it is of great potential benefit.

Not all the projects with an impressive early start can show a continuous growth line as can the PLATO and Stanford projects. By contrast, the CAI Center at Florida State, established in 1965, would seem to have lost its leading edge. There was some early impressive work that rapidly became well known, exploring new ways of using the computer in conjunction with other educational developments .
This was done in regular courses with a revised curriculum content in the physics department. At the same time, research in aptitude-treatment interaction contributing strongly to the main lines of development in this field in educational psychology was undertaken. There has been little evidence that their clearly effective materials have been syndicated elsewhere, or that the research element has continued with equal strength. Although the initial momentum seems to have lessened rather than increased, the centre is of course still active. In 1975, a PLATO IV system with 12 terminals became operational, and all high schools and universities in the state of Florida have access to it.

The University of Texas established a CAI Laboratory in 1965, which was also directed towards the research of possible uses of the computer in instruction. A major feature of their work has been the simulation of laboratory experiments.

CAI activity has also been continuous at the University of Michigan.
It began in 1959, with a project on the uses of computers in engineering education. The success of this project was instrumental in the establishment of the Center for Research on Learning and Teaching. There, faculty members have joined in projects to develop computer-based materials in science, social science and some professional areas. Work has also been oriented towards a general monitoring of work at large, surveying the interests of the educational community and the problems and progress of computer-based learning. A typical contribution in this area was CLUE (Computer Learning Under Evaluation)(Zinn, 1970).
This is a guide to information sources as well as an evaluation of the uses of computers in education at that time.

Neighbouring projects at Michigan State University and Wayne State University were also established in the early 1960's.

Cooperation between their staff, exchange of ideas and program, led in 1965 to a proposal to link the computer facilities of these three universities. This pioneering sophisticated network of a number of large central computers - a distributed network - was undertaken within the project MERIT(Michigan Education Research and Information Triad). A further project EXTEND was designed to extend the use of these combined resources to other universities.

One of the most productive centres has been Pennsylvania State University, and their materials have been widely used in institutions other than their own. Their CAI Laboratory has also undertaken research on student attitudes. The CARE project (Computer-Assisted Renewal/Remedial Education) is an important one in that it meets one of the claims for computer-based learning in catering for isolated students, and, indirectly, also contributes to the educational needs of handicapped children. The CARE courses enable teachers of ordinary, elementary grade classes to identify children who might be in need of special help, through being emotionally retarded, or handicapped in some way. A mobile van brings this instruction within the reach of teachers in remote areas who would otherwise be unable to attend classes. (Hall, 1973).

An important production oriented centre is at the Irvine campus of the University of California. In collaboration with IBM, a computer system was provided at the time that the school opened which would encourage the free and ready use of computers in all aspects of university life. Although this general exploitation has not altogether been achieved, the work of Bork and his colleagues in their physics department has been impressive. Their materials, which they refer to as 'dialogues', make extensive use of graphics terminals. A most interesting feature of the project is the streamlining of production, which has not been matched elsewhere in the questionnaire responses. University teachers design their instruction in the form of a flow diagram. Student assistants and typists see to the programming and putting the program into the computer. The teacher is then able to make whatever refinements he wishes, and the final results are computer-based learning materials of a high level of sophistication. (Bork, 1975).

Bunderson working at the University of Texas at Austin developed a teaching strategy, which incorporated 'learner control' during the early 1970's. The non-profit Mitre Corporation was developing an interactive cable television system at that time. In 1972 the NSF founded the TICCIT program, the hardware, software and courseware to be developed jointly by the Mitre Corporation and Bunderson's group, which had meanwhile moved to Brigham Young University (Bunderson, 1972).

The multi-institutional projects

MERIT and EXTEND have been referred to earlier. Further multi-institutional projects of importance at the present time are TICCIT, PLATO, CONDUIT and COMPUTE. Multiple-institutional in so far as it is a discipline related network, the Lister Hill Service is considered here, and it is also put into the context of Health Sciences and CAI.

TICCIT (Time Shared Interactive Computer Controlled Information Television)

The planning and implementation of the TICCIT project was described at the 2nd IFIP conference by the Project Director (Morrison, 1975). The National Science Foundation had sponsored a previous study under Bunderson at the University of Texas, where it was found that a major need lay in 'remedial' math and English at the junior college level. These courses were not popular teaching assignments for faculty, and about one third of all incoming students were in need of help. Today, one half of all students taking pre-calculus mathematics and freshman English composition at Phoenix College in Arizona do so through CAI. They do so through 128 computer terminals consisting of high resolution colour TV receivers and a keyboard incorporating a set of 'learner control' keys. These are described by Faust (1974). The terminals are serviced by two Data General Nova 800 series mini computers. This use of television terminals and mini computers are important features of this project, having as its major goal the cost effective provision of CAI on a large scale.

The project is divided between Brigham Young University and the Mitre Corporation, with Mitre developing the hardware and software and assuming responsibility for the project as a whole. BYU develops software and hardware design requirements and produces the software under subcontract to Mitre.

Another important feature of the TICCIT project is the organisation of the teams producing courseware. Teams are made up of educational psychologists, subject matter specialists, media specialists and programmers. The teams work according to production engineering techniques. A further major goal of the project is to demonstrate the feasibility of systematic courseware production procedures. It is reported however that independent evaluators have considered this standardization of procedures to have been premature (Hunter et al 1975, p. 170).

PLATO

The current (as of 1975) status of the PLATO IV system was described by the associate Director of the project, Dan Alpert, at the 2nd World IFIP Conference (Alpert 1975). A further recent article describes the PLATO courseware in university science education, and their research, and provides a further bibliography of the PLATO project than does Alpert's paper (Smith and Sherwood, 1976).

PLATO has also been designed to provide interactive CAI on a large scale. It is based on teacher-oriented preparation of materials. The student terminal on which lesson material is displayed is unique.

It is known as the Plasma Panel; it is 22 centimeters square, and it displays graphic information and colour photographs as well as text, without auxiliary storage. Students interact with the material through a special key set like a typewriter. The computer system is based on a large general purpose machine (Control Data Cyber 70 Series) with 4 CPU's, and it can serve thousands of pupils simultaneously over telephone lines. There are now 950 terminals, and more than 3,500 hours of instructional material available, in more than 100 subject matter areas. The age of the students ranges from that of the first school years to graduate students.

A further important feature of the PLATO project is the language that was used, TUTOR, which breaks away from the frame-oriented author languages. Authors can sit at any student console and write, edit or modify instructional materials. Student performance data can also be stored and manipulated. Since the network permits communication between any 2 consoles, this means that authors, who are essentially university teachers, can reach professional CAI consultants through the computer at any time.

Within the PLATO IV project, the wide range of instructional materials written has been designed to make use of the unique features of the PLATO IV terminal. While terminal incompatibility can be overcome, it still presents great problems. In order to make the features of TUTOR available to CAI projects without Plasma Panel terminals, HYPERTUTOR was developed by Schuyler, apart from the PLATO project. This will run on all CRT terminals (including PLATO IV) that have a screen size of at least 24 lines by 64 characters. To illustrate this wide range of available material, Smith and Sherwood describe segments of a few programmes in physics and chemistry. They include simulations, tests, and problem solving activity. Information-based materials help students design experiments and receive the experimental data which would follow their execution for them to interpret. Students can also gain experience in dealing with problems having many possible solutions. In the synthesis of organic compounds there are often many ways to proceed from initial to final product. The CAI computer does not impose a particular solution, but recognizes a wide range of acceptable routes. In short, the PLATO system permits a high level of interaction in these lessons, with student inputs in the form of answers to questions, predictions of the outcome of some experiment, parameters to be used in simulated experiments, and the interpretation of a set of data.

CONDUIT

This project has been described by Hunter et al (1975). The National Science Foundation has sponsored a project for the transport of computer-based learning materials between five university networks (North Carolina Educational Computing Service, Oregon State, Dartmouth, University of Texas). Together, they serve 300.000 students in 100 institutions. CONDUIT is a 'soft wire' network, there being no 'hard wire' connections between these regional networks.

The purpose of the project is to determine the central factors in the transportability of computer-based materials and to examine possible strategies to accomplish it. Documentation guidelines have been developed to this end. Committees of faculty experts have been set up for different disciplines to select materials worth transporting to other schools.

There have been a number of key workers who have given leadership to both educational and technical developments because they have computer competence of an advanced level as well as discipline depth. But these qualities are rare, and it would be unfortunate if the development of a CAI project had to await the emergence of such a leader if good results can be achieved otherwise. Within CONDUIT, the roles, tasks and necessary skills for curriculum coordinators are being assessed and documented. The value of training workshops in CAI is being assessed, as is the necessity of one-to-one consultancy.

COMPUTe

The COMPUTe project has been described by Hunter et al (1975), and by the project leaders themselves at the 2nd IFIP Conference (Morton & Luehrmann,1975). Preceding the EDUCOM study in its inception, they find themselves accepting Anastasio and Morgan's analysis of the factors leading to the lack of growth of computer-based learning, and consider that they are establishing strategies to combat 3 of these. These are:

1. Provision of good materials in quantity
2. Provision of incentives for authors
3. Establishment of a formal production/distribution network

Although they do not make it explicit, they are also directing themselves to a factor considered important in the present study; the institutionalization of CAI.

The COMPUTe project considers that the package of incentives that they have made available surpasses those available commercially to most authors. It includes summer salaries (there is no 'release time' concept), housing and partial travel expenses, while authors are at Darthmouth. There they can revise, refine and package their materials, with the benefit of student programmers,free computer time, portable terminals for home use, typing, editing and publishing services.

The project also provides 'guidelines and standards'. A major reason for the work of this project is that, although there are many thousands of imaginative computer applications in various courses, they are not usually used outside the environment in which they were produced simply because they are not available in a suitable form. As they stated in their proposal for continuation of the project "computer programs were seen as a possible starting point or a by-product, not a goal in themselves. We reasoned that most faculties conduct their courses along the lines established by textual material in their field. Therefore, if we wished to influence course content or methodology .... we should offer material in that form." (quoted in Morton and Luehrmann, 1975).
The project aims to provide camera-ready copy and negotiations with publishers as agents for the authors. These texts usually have a fairly short program - longer programs are handled by CONDUIT, one office of which is also at Darthmouth.

The place and purpose of these relatively small program elements is carefully considered in their 'Description of Project COMPUTe Materials'. They write:

"Simulations are frequently more fun to write and play with than they are useful as instructional tools ..... What ultimate objective should the student achieve as a result of working with the simulation? ....

Careful consideration of the instructional value of such a tool may make the difference between its being merely a game or a valuable resource."

COMPUTe has a Board of Overseers of distinguished university teachers who evaluate the materials produced, and see to it that they are used elsewhere by appropriate people. Most of the materials are in BASIC or FORTRAN.

HEALTH SCIENCES

The health sciences have been the most active of all graduate and professional groups in the instructional use of computers. There is a wide range of activity, including a discipline-oriented network, use of simulations and tutorial lessons, and individualized instruction.

The Lister Hill Network

The Lister Hill network provides a network for a number of medical and nursing schools and universities. Network users are categorized as trial or as operational users. As trial users, they must obtain a terminal in order to try out existing material, but they are under no further obligation. Operational users evaluate existing materials, and contribute to the network's repertoire. These operational users are selected on the basis of the quality of their materials. They must share these materials, and make their computer facilities available to other users, and also provide consultancy. Further, they are required to submit plans of how they will judge the educational effectiveness of materials.

In order to access the network, a user dials the nearest minicomputer, which connects him to the contractor school he wants. The service suffers to some extent from its own popularity - sometimes users cannot get access. The greatest difficulty is the high cost of communication, which accounts for about half of all costs.

Ohio State

Freshman students at Ohio State Medical School can choose between the traditional course and the ISP (Independent Study Program) for their first three years. There is an important computer-based element in the latter - the TES (Tutorial Evaluation System). This helps students obtain mastery of the subject matter to be learned, by providing them with formative evaluation - repeatedly assessing their understanding and giving constant feedback on their progress (Griesen, 1973).

University of Illinois

The University of Illinois is particularly well known for CASE - computer simulation of patients. CASE allows medical students to take full responsibility for a patient, and deal with unusual or difficult situations, at a much earlier stage in his medical career than could possibly be permitted with real patients (Harless et al, 1973).

CASE simulates the clinical encounter, and gives students feedback after the successful treatment of a 'patient', including the optimal path for diagnosis and treatment. The 'doctor' can ask the 'patient' questions over his symptoms, have tests, administer treatment, and adjust it as the 'patient' reacts. In most cases the 'doctor' can communicate successfully with the computer in his own words. The cases presented to him can be made gradually more complex, with one disease masking another, and so on.

Massachusetts General Hospital

Massachusetts General Hospital is well known for simulations of disease syndromes, biochemical models and clinical encounters. They are available for both undergraduate and practising physicians.

University of Southern California

Anaesthesiology residents can learn their operating theatre skills with a computer-controlled mannequin, SIMONE. The mannequin breathes, has a heart beat and blood pressure, opens and closes its mouth, blinks its eyes, and has both temporal and carotid pulse. The problems presented to the 'anaesthetist' can be made gradually more difficult, and particular phases can be repeated as found necessary. The physiological reactions take place in real time.

HARDWARE AND SOFTWARE

THE PROBLEMS OF CONFIGURATION, LANGUAGES, AND TERMINALS

Although there was interest within the R.U. Utrecht project to survey the present situation in these areas also, it has never been of central concern to this study. Some attention must be given to these issues however, since decisions made here will have profound effects on the future course of any project. A further review can be found in Levien (1972) and a briefer one in Hunter et al (1975).

The impression that has been gained within this survey is that instructional and organizational advances have not caught up with the potential offered by the hardware and software already available, except in isolated instances in a few scattered places. Once instructional and organizational strategies can be stabilised, the required hardware and software can be found to support them.

It has been recognized throughout that blanket decisions over instructional and organizational strategies of uniform application are not to be found. There is no possibility of consensus here, and so no easy path to guide a new, individual project in making correct choices. It is not only that, as in all computer applications, requirements, advantages and disadvantages have to be carefully balanced. What is more difficult is the impossibility of assessing requirements in a new project over any length of time. A particular instructional style may be preferred at one stage and be considered restrictive in another. The level of final usage is difficult to predict. The amount of involvement of teaching faculty is also unpredictable, so that the skills and needs of those who will do the actual programming cannot be set down.

Configuration

Simplicity of use, the adequacy of BASIC for many instructional purposes, low cost for reasonably low usage may suggest minis. Specialised CAI author languages, speed of response, large storage and reliability may indicate the preferability of larger computers. The advantages of sharing facilities, the specialization of expertise may lead to networks. Networks can be selected according to regional availability, or by discipline. Resulting savings in cost per unit of computation have to be set against increased communication costs. The possibility of keeping all options open, and supporting a range of applications and developments with access to a mixture of these systems has also to be considered.

Languages

Again, there are conflicts that make a straight choice impossible. A suitable language may save 20 to 30% programming time. It may not be within the scope of a non-specialist's skills, however. A CAI language may not only ease his task, it may have built in documentation, ease of monitoring student performance and so on. But, it may not be machine independent, and it may have excessive hardware requirements. A frame oriented language suitable for tutorial use may not be suitable for information-based programs. CAI languages have been evaluated by a number of authors. Two accounts that are available are for example Zinn (1971, 1972) and Leiblum (1975) and Lower (1976).

There were further papers of relevance at the 2nd World IFIP Conference (Scheepmaker and Zinn, 1975).

Terminals

The teletypewriter was the mainstay of computer-based learning for a long time. The CRT has become popular, but it costs more, much more with hard copy facilities. Graphics terminals are now generally considered essential. The plasma panel has many enthusiasts, and many would be enthusiasts who look for the hoped for price reduction and, through their awaiting it, are delaying it.

Some optimists extrapolate the downward curve of costs in computer systems and look forward to the possibility of 'personalized' home-based television terminals, with keyboard and cassette recorders. Then, individualized, extra-institutional instruction will have arrived.

COMPUTER BASED LEARNING IN THE NETHERLANDS

CAI began in the Netherlands at about the same time as in U.K., but, initially, on a much smaller scale. Although the first IFIP Conference on Computer Education was sited in Amsterdam, the local representation in the computer-based learning papers was slight. There were first two projects established in the Netherlands at that time, one led by De Klerk in Leiden, and the other by Dirkzwager.

Following this conference, there was a rapid growth of activity, so that a survey undertaken by Camstra in 1973 (Camstra 1973) indicated that six of the universities were hosting projects. By 1975, this had grown to eleven projects within eight universities. The representation at the 2nd IFIP Conference was stronger, with a number of papers presented (Scheepmaker and Zinn 1975). The Netherlands projects have recently been summarised for UCODI (Unité de Coordination de la Documentation et d'Incitation à la recherche) by Van Hees (1976a). His overview is in English. Several centres have also a number of other English language articles available in addition to their literature in Dutch.
The Netherlands CAI projects are individual, having grown out of the particular enthusiasms and interests of individual university teachers or researchers. Except for two S.V.O. (Educational Research Foundation) projects, they are all 'hard' money funded through their own university budgets. There is no national development program on the U.K. model, or large scale inter-institutional CAI projects as in U.S.A.

There is a large scale multi-institutional CMI project, which affects over one thousand students per year at the present time in no less than fifteen regular courses. This project has recently been described by Van Hees (1976b). Disappointment at Eindhoven in the results of a project with a feedback classroom, together with the observation of the frustration suffered by students under a group-paced regime, led to a project in individually paced instruction. An assessment of computers in education in Eindhoven and Tilburg led to the conclusion that the greater pay-off for a given investment is in CMI rather than in CAI. The work of individualized instruction was coordinated with the establishment of a CMI system which provided formative evaluation. Striking improvements in student attainments were obtained.

Before the introduction of the CMI system, between 40 and 50% of students (depending on the particular course) were passing their courses within the normal study period. Afterwards, this rose to 70-90%, and with further improvement of the system, to 85-90% . The system is now in use in the engineering faculties of several universities, and for statistics for psychology students in Tilburg Technische Hogeschool and Amsterdam.
The project has increased the number of students that can be enrolled on these courses, and has improved course evaluation, for a comparatively low expenditure.

There are three pilot studies for CAI, all three initially working with PLANIT, but with two now working largely in HYPERTUTOR. These projects have an emphasis on the production of materials for demonstration and finally for ordinary courses, and the development of appropriate strategies to ensure their implementation. One of the most productive centres in this regard is that at Nijmegen (Gastkemper and Leiblum). A number of materials in PLANIT have been developed and others from University of Freiburg and from American schools are also available.

Strategies for selecting and approving appropriate subject matters for CAI treatment, provision of internal and external training in CAI techniques, and the establishment of evaluation techniques are also important to the project. Concurrent work on the development of a versatile and reliable CAI system and language is also proceeding.

There are two universities in Amsterdam, sharing a common computer facility. A number of projects have been undertaken in both of these(Camstra 1976a) Camstra has recently reviewed his and his colleagues' work at the University of Amsterdam and given his perception of the future for CAI there. An early development was a CAI course in PLANIT on experimental design for 2nd year psychology students (Camstra and van Eck, 1973). This was followed by a course on instrumentation in psychology, also in PLANIT, but with some parts in BASIC. Returning from a tour of American CAI centres that included a visit to Schuyler at Northwestern, Camstra arranged for HYPERTUTOR also to be available. The most recent development by Breuker and Camstra is on 'intelligent' CAI, and was described by Camstra at the Conference on Improving University Teaching in Heidelberg this year (Camstra, 1976b).There is further discussion of this paper in chapter 2, 'The origins and contributory sources of computer-based instructional systems'.

The projects at the Vrije Universiteit at Amsterdam, are more research oriented. Bernaert is working on a comparison of learner control and program control. De Leeuw is investigating the computer-based teaching of problem solving. Dirkzwager is researching a computer-based responsive environment in teaching through computer-based testing with automatic scoring based on subjective probabilities. He is also concerned with system/software specifications for computers in education. Beishuizen is working on the problems and strategies of educational innovation with computers, and Van der Veer with programming language characteristics in education. In a number of projects there is an interest in aptitude-treatment interactions. Among this group, papers were presented by Dirkzwager and de Leeuw at the 2nd IFIP World Conference (Scheepmaker and Zinn, 1975).

Each of the university CAI projects works with its own computer centre, and these vary in their support for interactive computing in general, and computer based learning in particular. A project under the leadership of Wolbers in Delft is concerned with the design and implementation of a system for CAI based on a minicomputer configuration. The aim of the project is to establish a prototype system that is independent of author language. At present they are working on the translation of programs with author statements written in Coursewriter, PLANIT or HYPERTUTOR into ASA-FORTRAN. The system is not yet final, and the project is expected to run for a number of years. The present status of the project has been described by Wiechers (1975).

The establishment of such a system will be a major contribution to good communication between the different CAI systems available. There have been other cooperative projects, for example the debugging and implementation of PLANIT for several universities. There is also informal cooperation and dialogue within a users group, to which all those working in the field of instructional uses of the computer at tertiary level can and in fact do belong.

Until recently, it has been known as the 'CAI Consortium', and it had the official status of a working committe of the Academic Council (A.R.). This consortium has now been reorganized and renamed as the VOC (Vereniging voor Onderwijs en Computer; The Society for Education and the Computer). The present chairman of the group is Van Hees of the Onderwijs Research Centrum of the Katholieke Hoge school Tilburg).

This society seeks to promote further cooperative development of computer-based learning, with a sound educational research base. Further initiatives will be directed toward the attainment of appropriate, available and reliable computer facilities. At the present time, there is less emphasis on production and large scale implementation. The size of the country, density of the population and distribution of universities lend themselves to the sharing of facilities and cooperative enterprise.

COMPUTER BASED LEARNING IN CANADA

On reading the questionnaires received from Canada, an impression is obtained of a number of projects proceeding with an enlightened dependence on American work, and in complete independence of each other. There was little to indicate the influence, or even the existence, of a comprehensive national plan in 'computer-aided learning'.
It must be said that the questionnaires went to Canada when there was a postal strike, and so the number of responses received was comparatively low. They were also subject to some bias since several of the responses came from Montreal - the two Concordia campuses and also from McGill.

Canadian work in CAI is described briefly here in so far as it differs from American development. It affords the opportunity to indicate that there has been an extensive national plan for some years and the features of it that have been described would seem to be of interest elsewhere. It is also of interest to note how any developments in Canada are only undertaken after a thorough review of what is already available in USA, and a careful assessment of particular Canadian needs. This can be seen for example in Lower's study of the author languages available before creating his own (Lower, 1974).
It can also be seen in Hunka's and Romaniuk's analysis of terminals available in USA before supporting the case for a Canadian CAI terminal. (Hunka and Romaniuk, 1974).

The national plan for 'computer-aided learning for all' in Canada has been described from time to time by Brown, who has directed the project since its inception in 1967, together with his colleagues (eg. Brahan and Brown 1973, Brown 1975). He sees it primarily as a quality medium, but with important characteristics to increase the capacity and range of educational provision. Brown describes education as a great social leveller, but points out the difficulty of the universal provision of high quality instruction which has heretofore been the privilege of a wealthy elite because of the continually rising costs of education. Brown looks to CAL to supplement group instruction with what is needed to provide truly individual instruction. It is expected to extend rather than replace what a teacher does, to stretch the gifted, to extend infinite patience to those with learning difficulties, and to arrange for the home instruction of the handicapped.

The potential impact of CAI is considered by Brown to be so great, that it is essential to involve all educators and system designers from the start. The NRC (National Research Council) national plan has a network approach - it has to coordinate the creative innovators who produce the prototype materials, their careful evaluation, and the provision of a system that best permits and sustains these activities.

The system as a whole has been planned to have these further important characteristics. It will coordinate the whole range of audiovisual aids. It will make the courses, once they have been tried and tested, available to as many students as possible.

The importance of scale, and so of transportability, has led the NRC to develop a common author language and develop standard communication of what is available.

The development at a national level of such a project is hampered by the fact that education is a provincial undertaking, whereas research is a national concern. Thus, the NRC is developing the hardware and software for the project, but takes no part itself in curriculum development. In 1969 the NRC coordinated a committee to set guidelines for a CAI terminal. The terminal that has been designed for the project has a touch-sensitive graphic input tablet that overlays CRT. It was found to be popular, and successful for handicapped students in particular. Audio messages can be computer controlled through random access reel-to-reel tape controllers for lengthy passages, and random-access discs for short ones. Speech synthesis is used for greater economy and flexibility when speech quality is not important. Rather than depend on slides, as a previous Canadian CAI terminal did, video-tapes are used to provide single frame retrieval. Later, video discs will be used. (Hlady, 1973).

An 'intelligent' terminal which incorporates a plasma storage panel, a touch sensitive screen and a slide projector has also been designed. A lower cost version, with a television-compatible display, with the same software and digital storage is being developed as an alternative (Brahan, Hlady, Humphries 1975).

Besides designing and seeing to the development of the CAI terminals, the NRC has made available a dedicated DEC PDP 10 since 1969, for universities and other educational organizations across the country. Computer time is free of charge. The courses developed with these facilities are to be shared and evaluated by these educational organizations together.

In 1972 the NRC coordinated a working party of Canadian educators and computer specialists to set out the specifications for a national course authoring language, which became NATAL 74. Great emphasis has been put on transportability. A major part of the laboratory's effort has been devoted to the implementation of this language, since the efficient exchange of materials is so important to a national project.

Brown describes the NRC project as being set up with the express purpose of enriching and individualizing the education of all learners, at all ages and stages of learning. There is apparently particular concern for the plight of handicapped students. An example of this is given by the dept. of educational psychology of the University of Manitoba, that is cooperating with the project, and has set up a program for three special schools - one for the deaf, one for the multiply handicapped, and one for students with learning difficulties (Sandals 1975).

The picture of confidence in the future that is presented by papers describing this ambitious but promising NRC cooperative development program contrasts unfortunately with that given by the leader of one of the best known CAI centres in Canada, Lower of Simon Fraser. Lower considers himself to be in a unique position; having demonstrated the efficacy of CAI in a regular instructional context, only to have CAI support from his computer centre withdrawn from him, ostensibly because of insufficient faculty interest. Lower considers this in fact to be the result of the low priority of teaching in comparison with administration and research.

Lower's first educational technology project in the basic chemistry course was with audio-tapes. He made about twenty of these, each about forty minutes long, for different topics in the course where students had difficulty in problem solving. He considered that the successful integration of such materials into the course depends on the teacher being prepared to make appropriate adjustments for the perturbations that the introduction of a new element in the instruction give use to. Otherwise, such 'adjunct' use of the materials is just looked upon by the students as extra work. With integration, there was a marked increase in students' success with problems.
At a later stage of development of his course, Lower added CAI to these audio-tapes. But, for two consecutive years, he found no further improvement in his students' achievements. At that stage, he radically analysed and restructured his whole course. Previously, the course had been centred on 'lectures'. Now, it is centred on 'objectives'. This has allowed Lower to focus the materials more narrowly, and relate evaluation of students and materials to these objectives, with appropriate further action for each. The results have been significantly improved, not only for the students while in this basis course, but it is found that their better record is sustained in following courses. It suggests that they have obtained a sound basis with good problem solving skills for their whole chemistry course (Lower,1975)

The attention of Lower has been turned to CAI languages. Having reviewed the author languages available, he sets out the reasons for developing his own (Lower, 1976).

In Lower's view, the only explanation for Coursewriter's survival as an author language is that it is about the only way to use an IBM computer to provide CAI. He attributes the quality of the many successful materials that have been produced in Coursewriter to the skill and ingenuity of the authors rather than to fundamental properties of the language itself. A Canadian project that has made extensive use of Coursewriter is Hunka's and Romaniuk's in the Division of Educational Research in the University of Alberta. They have been operating a CAI system since 1965 on an IBM 1500. In their view, this system can exhibit outstanding capabilities for CAI when properly operated and supported. But if instructors proceed with the naive view that it will produce instruction on demand, then according to Hunka and Romaniuk they will surely be disappointed (Hunka & Romaniuk, 1974).

In addition to ensuring the good performance (including fast response time) of their computer system, Hunka and Romaniuk have also given attention to the development of a good CAI terminal. As other Canadian educators within NRC, they have deplored the fact that only one Canadian manufacturer has a terminal that approaches those of either TICCIT or PLATO. Characteristically, they support the development of a terminal designed for the Canadian market, rather than importing terminals from elsewhere.

The work of Mitchell and others at Concordia is also well known and has been described from time to time by Mitchell and his colleagues (e.g. Mitchell, 1973).
The use of computers in education has proceeded somewhat differently in Concordia. The work is attached to a two year master's degree course in educational technology. The students can work with a number of instructional technologies, of which CAI is one. There has also been an interesting use of the computer in EDSIM.

EDSIM is the computer simulation of a classroom - a set of learners - which serves both as laboratory for research and a game for student teachers. The game player takes pre-instructional decisions. The EDSIM model calculates coefficients for each decision and for each objective, updating measures of attention, motivation, instruction and capability for each student in the simulated population. It provides plausible instructional outcomes. Thus the game player can test the effects of alternative instructional strategies and try to find a 'winning' strategy.

There are a number of other centres of activity in computer-based learning and related research, both large and small scale, notably the University of Calgary. Several Canadian projects participate in the activities of American users groups, such as ADCIS (Association for Development of Computer-based Instructional Systems).

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS - I. General Development and scale of work

1. Base of operations

Usually, computer based learning units in U.K., Netherlands and Canada were based on an academic faculty, of which most were education/educational technology departments in Canada, and none were in U.K.
In the U.S.A., many more projects provided, and were sited to provide, university wide services, either in computer centres, or as independent units. Several were incorporated in Departments of Educational Resources, as was the case for 2 Netherlands projects. More U.K. and U.S.A. projects are directed through formal committee procedures, and coordinated in groups and subgroups of projects with simular interests.

2. Main stimulus to establish a unit

In all countries the overwhelming response was the importance of the initiative taken by one, or at most two to three project members. Neither Canada nor the Netherlands attributed much of their success to administrative support, but the influence of the NDPCAL in U.K. has undoubtedly been an important factor, which was formally expressed by some projects. Many U.S.A. projects also acknowledged the importance of high level administrative support. This was particularly so in the initial stages of work, when security and establishment was sought, with a broad institutional approach, and when resources had to be obtained in competition with other projects.

3. Main source of innovative effort

The U.S.A. responses were balanced between administration, faculty group, and individuals perceived to have provided the main innovative effort. There were some multiple entries. Several more recent projects were conscious of administrative stimulus, and several with established projects were reporting the importance of individual initiative at an earlier stage of their own development and that of computer based learning as a whole. Both among faculty groups and individuals there was a wide representation of subjects, with a predominance of Medicine among faculty groups.
The entries for Canada are similarly distributed, but with a predominance of education/educational technology among faculty groups.

This is in contrast with both U.K.and the Netherlands, where almost all the Netherlands projects report a major initiative from individuals, and almost none of the U.K. projects do so. The importance of administration and committee innovation, which in U.K. is supra-institutional, is also comparatively strong.

4. Staffing

The balance between educational psychologists/educationists, computer scientists, subject specialists, and students/graduate assistants in the countries surveyed is markedly different. In Canada and U.S.A. as a whole all these groups are roughly similarly represented, with a few more computer scientists then educationists, rather more subject matter specialists, and more extensive use of graduate assistants. In U.K. there are comparatively fewer educationists, and much more of the work is done by faculty members and less by graduate students. In the Netherlands, there is an apparently much smaller representation of subject matter specialists, although these may have been somewhat under-reported.

5. Direction of the projects

Rather less than half of the U.S.A. and Canada projects are directed through formal committees. Almost all the U.K. projects are so directed, but comparatively few of the Netherlands projects are. The American committees tend to be smaller than the British projects, which usually include some extra-institutional members, viz. the NDPCAL Director or his representative, the external evaluators Peat, Marwick and Co, and, on occasion, representatives from cooperating projects. Most of the Netherlands projects report that the groups are small enough to act as a unit, and require no formal committee at this stage.

6. Main types of resistance

Cost was a comparatively more important factor in U.S.A. than in other countries surveyed, and, importantly, it was so reported by many long established projects. Some new projects had free access to resources, or costs were hidden, but those who access other institutions have to pay heavily for services and telecommunications. The difficulty of funding further development after the initial stages had been passed was frequently reported. For the Netherlands situation , the difficulty of establishing posts was considered more of an immediate difficulty than costs per se.

Even in U.S.A., however, with a comparatively high level of administrative support and many institutions reported to be seeking a generally innovative image, inertia was as important a factor as cost. With the present established priorities of universities, and the current view of how faculty should spend their time and receive tenure and promotion, there is no external motivation for review and reform of instruction. Few faculty feel any personal need to alter their present techniques. This attitude was matched elsewhere.

Lack of knowledge and lack of confidence

were equal to cost as a factor in U.S.A. and Canada, and were considerably more important in U.K. and the Netherlands. Confusion between the different varieties of computer based learning, and a summary view that CAI was 'just another fad', inhibited faculty cooperation. It was also regretted that many embarked on extensive projects without an adequate appreciation of what was, or ought to have been, involved. There was a generally expressed need for an educational program for faculty members.

Lack of time for reconstructing courses was a much more important problem than lack of time to learn the necessary techniques. Faculty members spend a great deal of time on curriculum development, but there was a frequently expressed view that this is often in any case inadequately done. Many projects report that special computer techniques were not required, although a tendency for computer based learning to develop in those subject areas where there is already considerable use of computers cannot be ignored.

7. Main sources of resistance

In general, the problems of costs are understood and accepted, and the high cost of computer based learning, the responsibility of justifying and minimizing costs to colleagues are all acknowledged. Research rather than product oriented projects indicate in some countries (not the Netherlands) that they feel at a disadvantage in competing for funds, and some projects where computer based learning is not yet fully integrated into the curriculum are conscious that CAI can be considered as an expendable 'add-on' cost, and feel vulnerable as a result.

Competition with other projects manifests itself in several ways. The low priority that computer centres, or colleagues on computer users committees often give to CAI in comparison with research needs, is an indication of the importance given later in the questionnaire responses to CAI dedicated computers. Projects in scientific subject departments have to compete against expenditure on research equipment, and projects within education institutes find themselves considered as a minor interest of disproportionate cost in comparison with others of similar aims. Occasionally, absolute priority to other educational development areas, for example 'black studies', is reported.

Other general environment factors that hinder development can be grouped together as lack of knowledge and appreciation of computer based learning. Ignorance, fear of technology, and the fear of embarking on expensive projects when there is no guarantee of success, are all cited.

University teachers themselves have a number of commitments which must be met, in terms of teaching and administration. Where they have some freedom of choice in their activities, they will clearly direct their efforts where they will bring most reward, that is, in research. In contrast, teaching itself has low priority, and altering present teaching methods even less. There was suprisingly little negative influence from the possible fear that, in an environment where administrators are trying to 'improve' staff-student ratios, CAL enthusiasts might be programming themselves out of a job.

8. Obstacles to teacher cooperation

Very, very few respondents suggested that having to learn a computer language was an obstacle, the general view being that university teachers ought not to have to learn one in order to make use of CAI. The U.K. projects are mostly sited in departments where most teachers would in any case be familiar with computers, and in U.S.A. the bulk of the computer programming is carried out by graduate assistants or programming assistants.

Learning to construct self-instructional packages is, in contrast, a major problem, as is from time to time a reluctance to acquire the techniques of test construction and apply them to the development of test batteries. It seems to be generally the case that very few faculty appreciate the importance of specifying beforehand exactly what they want their materials to achieve, their scope, the sequence of activities, the interactions between student and materials. They embark on major projects with a lack of appreciation of what is involved, and as a result a great deal of responsibility is passed on to programmers and graduate assistants. While these have much expertise to offer, they lack the teaching experience required to permit them to explore alternatives and predict likely student difficulties. Several respondents compare authoring computer based materials with text-book writing in terms of effort and necessary skill, but the rewards are at present much less, in all respects.

Lack of incentives is such a pressing problem that, as will have been noted above, answers to this question were spontaneously given in the previous items, before they were expressly sought. It is evident that direct financial reward is not necessarily required, and might well not provide an answer to the difficulties. Adequate acknowledgement of authorship and recognition of computer based materials as publications is what is sought. One American project claims that the incentives problem has been overcome by persuading their Dean to accord recognition to authorship for self-instructional materials for the purposes of promotion and tenure.

No training, or follow up to training was only considered a problem by a few projects. It was considered that the major difficulty was to get teachers to make an initial involvement, and a lack of demonstration materials - and particularly a lack of demonstration of regular curriculum use of computer based learning materials within a reliable system - was considered to be of major importance.

A further problem is the idiosyncrasy of university teachers. They want very specific materials, and are often reluctant to accept the instructional strategies expressed in another author's self-instructional materials, but, as has been said, few are sufficiently skilled or motivated to write their own. This problem can only be overcome by involving more teachers in the early stages of the development of materials, so that they can identify with the final product. Something of this sort is essential to overcome the barrier of integrating materials into the regular curriculum. Whereas many teachers are happy to use CAI materials as adjunct, supplementary materials, few are prepared to let them carry a main instructional burden.

Although there is a general view that university teachers do not need to acquire computer skills, and that their best contribution can be made elsewhere, more than one respondent has a lingering suspicion that the main innovative problem is a general fear of technology, and a feeling of being intimidated by machines. To overcome this, educators have to be enticed into playing with a terminal. Once they learn to interact with it, the experience becomes fun, and their involvement is assured. In another context, another respondent suggests that one of the main contributions of using computers in test administration may be in breaking this initial barrier.

9. Use of materials from elsewhere in the initial stages of a project

Most of the U.S.A. projects used materials developed elsewhere in the early stages of their work. Of those that did not, there was a significant number of long established projects who could justifiably say that there was little to borrow in their early days.

It might be expected that there would have been a greater tendency to use materials developed elsewhere in U.K. and the Netherlands since projects developed there at a later date, but in fact the reverse is true. The tendency to try out what is already available before embarking on producing one's own materials is, at the moment, less.
A number of reasons have been put forward for this. Materials, particularly from another country, did not always fit into the courses that were established, and in the Netherlands there is a further language difficulty. Growing inter-institutional cooperation within individual countries may alter this. But, also within countries, program style and content from another institute was not always considered appropriate. There were software problems and other technical transfer problems.

These points, and others too, are to be found in the comments made by U.S.A. projects who had made extensive use of other materials, and the criticisms will be no news to the reader. It is evident that these are long standing problems.

10. Use of own materials elsewhere, level of adaptation and success

Usage of own materials elsewhere was possibly under reported, since some of the large cost projects known to supply materials on a large scale give no summary comment of this. There was a more optimistic response to this question than to the last. It would seem that the problems of a borrower are not always perceived by a lender.

11. Now that indigenous materials are available, to what extent are materials from elsewhere used?

The level of use of materials from elsewhere is still very low in Canada and the Netherlands, although one Canadian project was exchanging materials with Penn State, and two Netherlands projects were planning to utilise American materials. A further Netherlands project is also planning to use materials developed in the Netherlands.
In U.K. there was a fairly high level of use of programmes developed elsewhere, but this was exclusively confined to NDPCAL coordinated projects. Thus the NDPCAL figures really refer to exchange of materials concurrently under development.

The more extensive U.S.A. figures tend to refer again and again to a few sources and materials that have been tried and tested. The same names recur - PLATO, Mass. General Hospital, and so on. Technical problems seem also to have been largely overcome, through networking, common languages, transport and reprogramming at a new site undertaken as part of the service provided with the loan of materials. It would seem that the strategies worked out with these dominant projects could profitably be adapted elsewhere, to extend the successful wide scale use of a larger range of products. This could be done in conjunction with the notion of joint inter-team development and exchange of materials, with built in tranfer from the initial stages, such as is currently fostered by the NDPCAL.

12. and 13. Length and stability of establishment

In U.K., the number of projects predating the NDPCAL is small, and the feeling of dependence expressed on the continuation of this program is very high, for all the hoped for 'institutionalization'.

Although the Netherlands projects have by contrast been independent of extra-mural support, and grew informally from individual initiatives, there is a greater expression of a feeling of long-term security or permanency. The few reporting Canadian projects have very different origins - one is attached to a graduate educational technology department, another is in an education department, and yet another in a subject department. They all seem to look forward to a more or less indefinite future, although not one without difficulties.

A number of case studies have been encapsulated in the U.S.A. analyses from the U.S.A. returns, to indicate a pattern of various ways in which projects of various age have been initiated and developed. These have been reported as long-established, mid-term and new.
The long-established projects differ considerably from each other, and describe quite independent growth patterns. New projects, started since 1974, frequently show dependence on older development, and there is little evidence that any of these new projects is striking out in an independent line. This suggests that there will be a further coalescence of grouped interests when exchange and transfer problems are better under control.

14., 15. and 16. Materials available and their utilisation

The materials reported have been summarized in detail, with the terminal hours in regular instruction. The range of subject matter for U.K. is narrow - maths, engineering, hard sciences in the main - but there is a growing library of available materials and a reasonable level of student terminal hours per year. For the Netherlands, the range of curriculum materials also includes economics, psychology and sociology, but the number of programs available and the level of utilization in regular courses are less. Although there is a complete range of subject matter in the North American programs, there are many medical programs, programs for computer science, and also maths and science.
There are fewer materials for engineering subjects, and more remedial English (or EFL) than foreign languages. This latter point is possibly understandable with respect to the complexity of inter-media terminal sites that would be needed, the service which language laboratories already perform, and the necessity to coordinate instructional elements. The representation of 'dead' languages, such as classics and Old Church Slavonic , where the student is only required to master reading and writing skills, is of interest at this stage.

17. Factors contributing most to success

Technical

There were more specific points in this area from American projects, particularly long established ones, although several points recurred in other countries.

Many stressed the importance of a reliable, dedicated system with a fast response time, and the importance of computer graphics. Materials need to be of good quality pedagogically, relevant, available in some variety, and catering for a high degree of student interaction. Here and elsewhere several respondents warned against dependence on an inflexible system. One project suggested that 'hard' scientists and engineers engaged in teaching and with computer experience were more likely to provide this than either educational technologists or computer scientists. Others echoed this with a plea not to restrict activities to a particular learning theory approach. The siting of terminals within a CAI Centre was considered important by some, although elsewhere an innovation strategy suggested was to scatter CAI terminals at strategic points over a campus.

Organizational/sociological

In this section, the same points recurred. Most frequently commented upon was the importance of an energetic, dedicated and knowledgeable central figure who could give leadership over the range of activities, and an enthusiastic, cooperative group prepared to put in a strenuous work day over a long period of time.

Top level administrative support and 'hard' funding within an institute, or official dependable outside support and funding outside it were appreciated. A 'core' group of interested, innovative teaching colleagues prepared to cooperate, and their demonstrable successful integration of some computer based learning materials with the regular curriculum, was also frequently mentioned. Curriculum changes, changes of scale or organization, the relevance of certain research interests, could occasionally provide a setting for CAI, for some mutual benefit. Initial student success with materials and with the system lead to the appreciation of CAI by the clients who really matter, and their consequent readiness to study at irregular hours, which greatly improves the intensity of use of installation and cost-benefit calculations.

Further factors mentioned were the importance of good publicity; and, from projects accessing one of the major project networks, the success and leadership of these was also gratefully acknowledged.

II. THE PURPOSES OF CAI PROJECTS

1a. Project objectives

There is an unfortunate international tendency to manage the establishment and development of CAI projects in the absence of thoroughly discussed, formally agreed, project objectives, which makes it difficult at times to try to work out just where all this activity is heading. The few research oriented projects were often scrupulous exceptions. Usually, project objectives were in any case few, and related to only one or two of the possible areas. The full range of objectives is summarized below.

a. Research

1. Artificial Intelligence.
2. Learning styles, new methods in CAI, their effects, and aptitude-treatment interactions.
3. General investigation of the scope and feasibility of computer based learning materials.
4. Investigating and facilitating class management decisions, using a computer to simulate a classroom.

b. Educational

1. Course enrichment
2. Individualized instruction, mastery learning, and the establishment of instructional systems to maximise the educational success of all students.

c. Implementation and Innovation

1. Appreciation of computer based learning through the whole educational community.
2. Implementation of computer based learning in regular courses on a wide scale within and between institutes.
3. Implementation of off-campus CAI with non-traditional students.

d. Technological

1. The establishment of computer software systems and computer languages to support the goals outlined above.
2. Systems, documentation and design of material for reliability and ease of transferability, ease of student use, authority, editorship, collection and analysis of student performance data.
3. Remote capability, improvement of terminals and enrichment of terminal sites.
4. Student control of presentation.

e. Financial

Design of a comprehensive system and an instructional, computational service for institutions and home use of computer based learning materials, with proper accreditation, and at a low cost.

1b. How objectives are arrived at

Most projects have arrived at their objectives informally, or their objectives have evolved with project development, and reflect the present personal views and aims of project members. It is rare to find that they have been based on a feasibility study, or subject to committee decision or administrative consultation. In a few cases in U.S.A., and in all the U.K. projects, objectives were formally established having been agreed in conjunction with an external grant agency.

2. Which of the objectives reported were considered to be of most importance

There was no U.K. project with multiple objectives giving priority to research, a few in Canada and U.S.A. and proportionally more in the Netherlands. The establishment of appropriate systems still claims a great deal of prior attention. U.S.A. and U.K. had proportionally more projects concerned with overcoming specific educational problems and first and foremost seeking production and implementation of materials.

	HIGH	MEDIUM	LOW
research on student learning	9	13	23
individualization of instruction	33	9	4
mastery learning	21	10	14
evaluation of course elements	5	18	23
effecting organizational change	4	5	37
increasing capacity of educational provision	15	17	12
increasing teaching effectiveness	24	11	9
decreasing students' learning time	12	8	24
decreasing teachers' teaching time	4	9	31
decreasing teachers' record keeping time	6	10	28

RATED IMPORTANCE OF SUGGESTED REASONS FOR DEVELOPING COMPUTER BASED LEARNING

III. Rated importance of suggested reasons for developing computer based learning

Overall, the most frequent underlying goals of computer based learning were said to be the facilitation of individualized instruction and mastery learning, and the general improvement of teaching effectiveness. There is little drive to reduce the teaching or record keeping load of teachers, which contrasts with a reasonable level of interest in increasing the capacity of educational provision. Presumably a distinction is being made between the wider use of present resources, and the introduction of practices which might encourage economies in an on-going situation. Organizational change is not anticipated through more widespread use of computer based learning. It may be thought that the individualized learning that is looked for would require some level of organizational change and the support of computers in its attainment, and so this general view is a little surprising. It may be influenced by a consideration of what from a CAI project can be effected.

There is more concern for saving the time of students than that of teachers, and there is sporadic interest (which usually goes deep when it occurs) in the use of computer based learning for research purposes.

IV. Training of non-specialists and consultancy services

1. Courses

	Yes	No or not relevant
Courses in author languages	18	13
Courses in instructional design	11	23
Advice and consultation for beginners	31	2

There is a high level of provision of informal advice and consultation for beginners, sometimes following introductory courses, and sometimes the only method for new recruits to get into the field.
A fairly high proportion of projects give courses in author languages, but comparatively fewer offer courses in instructional design. This is in marked contrast with the obstacles to the development of computer based learning that have been perceived and reported by respondents.

There was a general view that the learning of computer languages was no problem. A major difficulty was the lack of appreciation of what was, or ought to be, involved in the design of instruction, particularly of self-instructional materials, and there is an unfortunate tendency to delegate instructional design to graduate assistants and programmers who lack teaching experience.

It must be acknowledged that courses will be established at this level to meet the needs of the situation as the ordinary university teacher feels them, rather than what CAI projects would like to impose on their colleagues. There was no mention of general appreciation courses, although demonstrations are clearly commonly available. Some coordination of these with an appreciation element and an educative/selling approach would seem to be generally lacking - it was only mentioned when its absence was occasionally deplored.

V. Courseware Development

1. Decision Basis for Topic Selection

CAI group directors and practising teacher	3
CAI staff and practising teacher	6
CAI staff alone	5
teacher alone	19
committee (and practising teacher in one case)	4

It will be noted that, overall, the decision to make a computer based learning package for a particular topic is made more often by the individual university teacher concerned, acting alone, than by all the other means put together. The tendency for this is much lower in U.K., where there is a much more closely integrated, formally structured overall program of development. It is also not true of the Netherlands situation, but this may just be a reflection of the generally lower level of involvement of subject matter specialists noted in I.4 and a lower level of production of materials for use in regular courses.

Criteria for decision

At the present stage of development, there is a tendency to encourage any efforts, the main criterion being the enthusiasm of the teaching faculty involved and their preparedness to use the materials in their regular classes.

Where projects are in a position to be selective, then a number of other characteristics are sought, which can be grouped and summarized as follows:

1. Relevance to current educational problems.

2. Priority to frequently given courses, courses with large numbers, where teachers need support and CAI will have a maximum level of impact for a given investment.

3. Priority to infrequently given courses with small student numbers that would otherwise use university faculty inefficiently.

4. Conformity to particular educational models and opportunity to exploit particular properties of computer based learning (interactive information handling capacity, individual pacing etc.)

5. Likelihood of materials produced being amenable to transfer.

2. Who constructs the packages?

(several multiple entries)

	Yes or occasionally
CAI specialist alone	1
teachers and specialists	39
teachers alone	16
teachers plus graduate students	17

3. Who sets the package in courseware?

In Netherlands, U.K., and all but one of the Canadian projects, there was no differentiation between the construction of packages and setting them into courseware. In U.S.A., there was a clear difference of task here. Very few faculty authors carried out this task themselves. Actual programming was done by unit programmers, students, and in two instances materials were typed into the computer by typists.

4. Courseware evaluation

Who evaluates the courseware developed?

external evaluation	6
specialist staff in CAI group	10
teachers and project staff who developed the materials	14
students and colleagues	6

Some projects explicitly responded 'not much done', etc.

The distribution of those concerned with evaluation is an indication of the generally informal level at which this is at present undertaken, as summarized below.

How? (there are some multiple entries)

rigorous statistical analysis	2
records of student responses and other program events learning time	12
pre/post/transfer tests of achievement	11
student usage and expressed interest, interviews	7
student attitude questionnaires	10
subjective evaluation by faculty and project staff	12

Some of the projects not carrying out any evaluation procedures gave reasons to justify this. The group 'subjective evaluation by faculty and project staff' is very likely to have been under reported! Several projects gave no, or scant, replies. The perceptive observation by one project leader that 'faculty members think they know when materials are working', is probably capable of a high level of generalization.

With what results?

rejection/revision expressly stated	12
good	10
fairly good	3
poor	1

It is a minority of projects that spontaneously describe the use of an evaluation-revision cycle and explicitly state that a number of iterations of this cycle, with consequent course modifications, are undertaken. Many comments were of a general, impressionistic nature. The one comment 'results poor', was from a group that is seeking to establish satisfactory evaluation procedures and is more than usually conscious of the difficulties.

VI. Expectations of computer based learning

(some multiple entries, for which the comparative comments are reported in the separate analyses of the preceding chapters)

big stand-alone (CAI dedicated or mixed)	28
stand-alone dedicated mini (or micro)	35
computers in networks	39

Few respondents felt able to make a clear-cut choice, and for those who could make a firm positive (or negative) comment in one direction, there were usually balancing comments expressed with equal crispness in the other. There was however a massive declaration for 'it must be dedicated'. A few comments, some from large scale projects, suggested that a modern educational environment will have access to all three of these possibilities. Computers will become more specialised in future, and their use will become more situation dependent. Many aspects of this specificity can be surmised from the individual comments that have been reported.

2. Terminals

	Paper	V.D.U.	Plasma	T.V.
Yes	17	38	17	27
Possibly	5	3	9	4
No	6	-	7	4

V.D.U.'s seem to be the majority trend, with some reservations concerning costs of hardcopy facilities, but no respondent doubted that V.D.U.'s have an important future.

The colour and graphics capabilities plus universal home availability of T.V. also have great appeal and considered potential for the future of CAI. There was some criticism of the resolution of roster generated characteristics, and some indicated their view of the necessity of a keyboard (which, say some, makes it a CRT).

Some respondents voiced the general tendency to await the further development and success of the TICCIT project before making a firm judgment. The plasma panel has many devotees, but is much criticised at present on the grounds of cost, and the non-realization of forecast price reductions is having a negative effect. Although paper terminals are being overtaken by other developments, few respondents would as yet declare them obsolete, and the majority view is that there is still a use for them in many applications in most projects.

A mixed, flexible approach is anticipated, and various possibilities are outlined in the free comments. There is a general expectation that the best of audiovisual technology and CAI will merge to provide much more sophisticated terminal sites than those at present available.

3. Systems Software

Standard languages	15
CAI languages	11
Mixed development	34

Few expect author languages to take the main burden of computer based learning, although there are some respondents who anticipate that they will dominate the field. Rather more, particularly those concerned with simulation, problem solving and CMI, expect standard languages to 'be sufficient', some anticipating the availability of higher level standard languages. The majority expectation is for mixed development. But a conflict arises from holding simultaneously the views that, firstly, a programming language environment should have a variety of languages available, including those developed by particular institutions for their own specific need; and secondly, it is necessary for languages to be available on a variety of computers, large or small, to ensure transferability. With the shift of the burden of programming from university teachers to programming assistants, the problem needs to be considered as one of improving man-machine communication and transferability rather than ease of authorship and editing for non-specialists in computing.

VI. . Expectations of Computer Based Learning (continued)

Lesson Style, Development and interchange

Lesson Style

Test Administration	41
Drill and Practice	31
Simple Techniques	25
Complex Learning	47

Several respondents indicate that all techniques are made use of in a CAI lesson of any magnitude, and others indicate that higher level computer learning materials subsume lower level simple techniques. The confidence and popularity of using computers in complex learning is unmistakeable, and it will clearly claim a lot of attention from present respondents, particularly when graphics terminals become more sophisticated and generally available. The place of the computer in test administration is generally recognized, and some indicate the value of using computers in test administration as an entry point, affording an opportunity to involve faculty members who may later participate in CAI. A number of 'modes' under 'other' are indicated, including simulation and gaming (which may have been thought by some respondents to cut across the categories given); information retrieval oriented CAI, and the production of exercises by students for other students, for their mutual criticism and extension.

Development of materials

	Individual	Team	Commercial Company
Yes	21	48	9
Possibly	5	2	7
No	3	-	3

The overwhelming view is that programs will be written by teams in the future, such teams to include groups of teachers with a common interest, and with appropriate back-up staff. Many expect that the most important initiatives will continue to come from individuals. None of those anticipating a major input from commercial companies at this level do so with much enthusiasm. Some are equally pessimistic in their expectations of what teams will produce.
But it is evident that the increasing sophistication of CAI will make tremendous demands on an individual who wishes to break new ground. It is encouraging that the general expectation is that such leaders will continue to appear.

Interchange - how it is most likely to come about

	Grouped comments	Related isolated comments
Commercial companies	5	or, keep them out!
Clearing house	13	government support needed
Users groups, conferences	4	
Publications, documentation	1	
Institutes with similar aims/coordinated course development	8	
Centralized systems	12	or, portable systems
Standardization of software	9	or, build translation routines
At user level	6	

In addition to the categories of response given, there are several respondents who also point out the difficulties, their lack of optimism, and their expectation that the next five years will continue to be unstable, so that in their view the simpler, and the more portable the system, the better.

Commitment and further free comments

Comments from U.K., Netherlands and Canada were short and expressed in general terms, usually indicating a general continuation of present interests but within a framework of some uncertainty over the future.

Some comments from U.S.A. were also expressed in this way. There was also a wealth of specific comment, indicating that a rich variety of development over the whole field of computer based learning and supporting systems and software can be looked forward to. Further helpful comment and advice from old established projects to a new one were also given in this context, and this indicates the level of responsibility such projects have taken upon themselves in the future development of computer based learning.

2. SUMMARY AND RECOMMENDATIONS

1. In the first place, the inadequacy of the Anastasio and Morgan (1972) analysis of the situation needs to be recognized.

   Anastasio and Morgan found the most pressing problem to be the lack of good prototype materials, and the second to be cost.

   In this enquiry, cost was not found to be an overriding factor. There is certainly a lack of demonstration materials.

   Anastasio and Morgan have set up a model of the problem of the lack of growth in computer based learning in terms of a circular pattern of arguments. In their view, the circle can be broken by an input at any point in it from commercial or government sources. This would lead to a 'critical mass' of materials and support, after which computer based learning would be self-sustaining.

   Were 'computer based learning' to be deleted from their arguments, and programmed instruction or educational television or whatever placed there instead, the diagram and arguments would not have to be changed in any way. There is nothing specific to computer based learning in their analysis. A breakthrough cannot be expected just on the basis of an injection of 'soft' money facilitating the production of prototype materials. Though it would, of course, be helpful.

2. A more basic problem lies in the underlying problem of institutionalization. The distinction has been drawn between 'hard' money, from a university's own budget, and 'soft' money, from some grant agency. Problems have repeatedly been encountered in projects when the 'soft' money stops.

   In order to circumvent this, the NDPCAL in U.K. has insisted on equal funding from host institutions, so that there is a 'hard' money input from the beginning of a project. Readiness to provide such 'hard' money has been taken to be evidence of institutionalization of computer based learning and an indication that it will survive the withdrawal of 'soft' money.

   There has been further repeated evidence that such a conception of 'institutionalization' is too superficial to be useful. A course, department or institute will benefit from and give support to an innovation when that innovation fits into a general framework of development and is directed to clearly perceived and valued goals.

   Institutionalization implies compatibility with overall, systematic, concurrent development. It needs to be sought in any innovational undertaking.

3. An innovation such as computer based learning that requires such a large initial investment needs to pursue economies of scale, which require inter-institutional cooperation. Conformity to the requirements of a group of cooperating institutions is likely to conflict with what is considered necessary to penetrate and revitalise the educational provision of one particular institution. Strategies need to be developed to identify topics and objectives that are shared, and to create, evaluate and implement materials that can be 'institutionalized' in a number of institutions concurrently.

4. Such cooperative course development has to be carried out within the context of a thorough-going analysis and restructuring of the course that will incorporate the materials. It has frequently been indicated that, where CAI materials are not well integrated into the regular courses, they will be perceived by the students as extra work, and treated as such. There has been very little evidence of a systematic approach to the establishment of computer based learning in regular instruction. The lack of curriculum building and instructional design skills was shown to be a greater problem than lack of computer skills. If it is difficult for a CAI group to entice university teachers into undertaking the creation of computer based learning materials, how much more difficult is it to persuade them to undertake such background work. It is usually seen to be outside their brief.

   The introduction of computer based learning needs to take place in a context of overall development of educational provision.

5. There are a number of conflicts within computer based learning that mark it off from other areas of educational technology on grounds other than scale of investment.

   It has to be recognized that there are no straight choices possible in computer based learning at present, and hence no consensus view. There are advantages and disadvantages in all the computer languages, particular computer configurations, terminals, and so on. None wins on all points. Thus, there is a necessity at the present time to leave options open, and this conflicts with the desire to ease exchange of materials, cooperative development, and access to a number of computer facilities, through standardization. Solutions in the present state of computer based learning can only be partial. Projects selecting the same particular solutions need to find each other through a range of 'hard' wire and 'soft' wire networks. The possibilities of multiple group membership, and also of independent individual experimentation need to be preserved.

6. A careful analysis needs to be made of where the greatest pay-off for a give investment, particularly an initial investment, lies. It is evident that this has rarely been done, except by some enthusiasts for computer managed instruction, and those concerned with college level service and remedial courses. CMI seems at present to be overshadowed by CAI. Enthusiasm among CAI specialists is directed at present at facilitating complex rather than simple learning. because of its interest and challenge to the innovator rather than to meet particular educational goals or solve particular instructional problems.

7. An overall analysis of gains for particular computer based learning strategies is only possible in a comprehensive research and development program that incorporates a range of computer based learning types and styles, and a range of instructional problems and situations. The application, implementation and interpretation of such a program needs the background and techniques of both fundamental and applied psychological and educational research. Such scope will probably be beyond one project or even one institution,so that an inter-institutional research and development effort, with mutual respect for the contributions from all sides, is needed.

8. With all the necessity to design systems well it must not be forgotten that the final goal is their implementation. At the present stage of computer based learning, inter-related research, development and implementation objectives are appropriate.

   Implementation and production must at the end of the day predominate if computer based learning is to fulfil the claims that have been made for it.

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Computer Assisted Instruction
Computer Managed Instruction

Questionnaire - Rijksuniversiteit Utrecht Project
CAI/CMI in tertiary education

The CAI/CMI project of the University of Utrecht has recently been formally established under the auspices of the University Council. Although it is for the benefit of the University as a whole, it is sited in the Education Section of the Physics Department, for at least the historical reason that this is where early initiatives were taken.

A preliminary study of the literature and personal encounter seem to suggest that such antecedents, the resulting siting of projects and composition of research and development groups, may have an important bearing on the type and scale of work undertaken, variations in the sort of support or problems encountered, and differences in the pattern of growth and development. Such aspects of CAI/CMI and their implications are rarely directly reported, however. It seems to us that, at this stage of development of CAI/CMI, it is important to build a fuller picture of the various alternatives that have emerged and are emerging, not only to give substance to recommendations we may be called upon to make for our own university, but for others who are interested in the evolution of CAI/CMI, and what can direct this evolution.

The deadline for the completion of this overview is January 1976 and it will be necessary for us to begin the analysis and summary of the questionnaires in November 1975. Your help in sending us the information requested in as much detail as possible and as soon as you can, will be very much appreciated.

We are aware of the limitations of questionnaires. The questions are intended to focus attention on areas likely to be of importance, and the options that follow each question are meant to cue suggestions or indicate an anticipated form of reply rather than to place constraints. Space is provided after each question for specific comment and further elaboration.
Further comments on aspects not already covered will be welcomed.

Please return the completed questionnaire to us at the following address:

Dr. C.A. Hawkins
Drs. F.E. van 't Hul
Afdeling Onderzoek en Ontwikkeling van Onderwijs
Rijksuniversiteit Utrecht
Maliebaan 5
Utrecht
The Netherlands

☐ Please indicate with an "X" if you would like a copy of the report when it is available, and if so, check that the address label on page 1 is correct.

RIJKSUNIVERSITEIT TE UTRECHT

CAI PROJECT

I. General development and scale of work

1. How is your unit or project in Cai established?

   examples

   1) based on an academic faculty or department
   2) based on a computer centre
   3) directed by a committee
      if so, to what body is this committee answerable?

2. What in your opinion were the original and most powerful pressures and initiatives that led to the setting up of your unit?

   examples

   1) student pressures
   2) pressure from a general program of modernizations of teaching methods
   3) initiative from one or two teachers in a particular department
   4) initiative from administrators or committees concerned in general with the economics, efficiency and effectiveness of educational provision

3. Describe the group that had the drive and the expertise to initiate the project.

   eg.

   1) high level administrators
   2) committee
   3) particular faculty or department
   4) a group of staff from different disciplines.
      If so, which disciplines?

4. Describe the present constitution of the group and their background.

   eg.

   1) educational psychologist
   2) other educationists (specify)
   3) other behavioural scientists (specify)
   4) computer technologists
   5) university teachers (specify discipline and specialism)
   6) students/graduate assistants (specify discipline and specialism)

5. Describe in detail the constitution of the administrative body or steering committee that directs or oversees policy and activity.

eg.

1) how many members
2) general administrators
3) department heads or departmental representators. If so, type of department from which they come
4) a department teaching computer science
5) a department providing a general computer service
6) a department teaching educational science(s)
7) a department providing an educational development service
8) a department (faculty, subject group etc.) teaching a subject other than computer science or educational sciences

6. What sort of difficulties and/or arguments had to be overcome in order to establish the project?

eg.

1) excessive cost of CAI/CMI
2) lack of knowledge of CAI/CMI
3) lack of confidence in CAI/CMI
4) reluctance to alter present methods
5) reluctance to find time to cooperate in restructing courses
6) reluctance to find time to learn necessary techniques

7. Can you identify the sources of these resistances?

eg.

1) cost-dominated administrators
2) pressures on teaching personnel
3) fear of teaching personnel that they could be displaced
4) higher priority of other projects (please specify)

8 What do you regard as the main difficulties in involving university teachers to cooperate in CAI?

eg.

1) difficulty of learning computer language
2) difficulty of constructing self-instructional materials
3) lack of incentives for teachers to take part
4) lack of resources to provide training
5) lack of resources to provide follow up to training and consultancy services?

9. Before you constructed your own courseware, did you make use of materials developed elsewhere?

1) with what success
2) what detracted from success

10. Now that you construct and develop your own courseware, are these made use of by other institutions?

    1) what amount of adaptation was needed?
    2) what was the level of success?

11. Now that you construct and develop your own materials, do you still make use of materials developed elsewhere?

    1) from what sources?
    2) what level of adaptation are you prepared to undertake?

12. Give a brief history of the events that led to your present programme.

13. Is your unit a pilot project, or is it permanently established?

    1) if it is a pilot project, for how long is it established?
    2) for how long do you expect it to continue?

14. Describe the instructional materials that you now have available and the scale of computer assisted instruction.

    1) how many lessons do you have available?
    2) indicate at what level they are - basic / secondary / tertiary (i.e. school) (university etc.)
       how long
       and in what subject areas

15. Do you have other computer administered materials that are utilised in the instructional process, but that would not be described as lessons?

    1) if so, what are they?
       (e.g. test batteries, data bank for a suite of programs, 'paper patients' available for multiple purposes)
    2) and how many do you have?
       (e.g. how many sets of test batteries, how many data banks)

16. What are the total student terminal-hour associated with computer assisted instruction?

    1) in regular instruction
    2) in development and trial of new materials for use in regular instruction
    3) in research projects (e.g. in student learning) apart from regular instruction

17. What do you consider to be the factors that have contributed most to the successful establishment of CAI/CMI in your institution.

    1) within your project group
    2) outside it

II Purposes of the project or unit

1. Do you have a formal list of objectives for your project?
   If so, what are they?

   How were they arrived at?

   If not, what do you consider them to be?

2. Which of these objectives claim most of your emphasis and attention?

3. What in your view is the order of importance of the possible reasons for developing CAI/CMI?
   If you do not wish to consider CAI/CMI as a system, then please indicate the rank order for either one of these above, or both separately according to your preference.

   - facilitating research in student learning
   - facilitating individualization of instruction
   - facilitating mastery learning
   - facilitating evaluation of course elements
   - facilitating organizational change in your institution
   - improving capacity of educational provision
   - improving effectiveness of educational provision
   - reducing time spent by students in learning
   - reducing time spent by teachers in teaching
   - reducing time spent by teachers in testing and administration of student recors
   - etc.

III Technical aspects

1. Describe the configuration of your computer.

   eg.

   1) what type is it?
   2) what is the total available core?
   3) is extended storage (e.c.s.) utilised?
      If so, how much, and what for?
   4) is background storage (disk and tape) utilised?
      If so, how much, and what for?
   5) are there any peripheral devices in use, and if so, what are they?
   6) is it involved in a network linkage?

2. Describe the terminals in current use.

   eg.

   1) what type are they?

2) how many are there of each type?
3) what, as a result of your experience, is your opinion of them?

3. What are your costs in running your computer, in terms of:

1) CP Load
2) IO load
3) data transmission

4. Describe the software aspects of the system

1) what standard compilers, general purpose languages, and CAI languages are used?
2) were they delivered by a software house?
3) were they self-developed?
4) are they satisfactory?

5. If the software aspects of the system were self developed

1) what manpower was available?
2) was this a free service?
If so, where from?
3) did the manpower have to be accounted for within your project/department?

6. Describe how your computer is used

1) is it: dedicated?
batch?
timesharing?

2) if there is concurrent batch and interactive operation, how is priority allocated?
3) what is the average time up?
4) what is the average time down, for:
-scheduled maintenance?
-unscheduled?

5) what is the average frequency of time down?
(occurences per day?)

IV Training of non-specialists and consultancy services

1. What provision is made for practising university teachers to acquire the techniques necessary for developing CAI materials?

   eg.

   1) formal courses in author languages
      - how many participants?
      - how many hours of formal study?
   2) formal courses in instructional design
      - how many participants?
      - how many hours of formal study?
   3) informal advise and supervision for beginners
      - how many participants?
      - how is this implemented?

2. What further consultancy services are provided?

   eg.

   1) problems of computer implementation
   2) instructional design
   3) evaluation

V. Courseware development

1. Who decides what topics will be developed into computer administered learning materials?

   1) Have criteria for such selection been made explicit? If so, what are they?
   2) If not, what do you consider them to be?

2. Who constructs the learning packages?

   eg.

   1) teachers acting alone
   2) teachers in cooperation with students (specify level)
   3) and/or in cooperation with specialists designated to provide such help. If so, specify discipline and specialism

3. Who sets the learning packages in courseware?

eg.

1) the group as described in the question above
2) the group in conjunction with additional personnel (specify)
3) a different group (specify)

4. Who evaluates courseware?

How?

With what results?

VI The future

How do you envisage future general trends in the following aspects of the overall development of CAI/CMI?

1. Configuration

eg.

1) big stand-alone computers (dedicated to CAI or mixed)
2) stand-alone dedicated mini (or micro) computers
3) computers in networks

2. Terminals

eg.

1) paper
2) visual display unit
3) plasma
4) TV

3. System software

1) standard languages (APL, FORTRAN, BASIC etc.)
2) CAI languages (PLANIT, COURSEWRITER, TUTOR etc.)
3) mixed development

4. Lesson style

1) test administration
2) drill and practice
3) simple techniques
4) complex learning

5. Lesson development

   1) by whom: -individual
   - team. If so, how constituted?
   - commercial company. If so, how constituted?

6. Lesson and system interchange

   1) where it is likely to occur
   2) how it is likely to be facilitated

To what extent do you consider that you will be identified with the trends you anticipated? Where you will not be so identified, to what factors do you attribute expected differences?

VII Further comments